Bacteria TMDL Development for Tributaries to the Potomac River: Sugarland Run, Mine Run, and Pimmit Run

Submitted by:

Virginia Department of Environmental Quality

Prepared by:

THE Louis Berger Group, INC.

August 2013

Table of Contents

List of Figures

List of Tables

Executive Summary

This report presents the development of the bacteria TMDLs for Sugarland Run, Mine Run, and Pimmit Run. These waterbodies were listed as impaired on Virginia's 303(d) Total Maximum Daily Load Priority List and Reports (VADEQ, 2010) because of exceedances of the state's water quality criterion for *E. coli* bacteria.

Description of the Study Area

The Sugarland Run, Mine Run, and Pimmit Run watersheds are located in Northern Virginia. Sugarland Run is located within the borders of Fairfax County, Loudoun County, and the Town of Herndon. Mine Run is located in Fairfax County and Pimmit Run is located in Fairfax and Arlington Counties. All streams are tributaries to the Potomac River.

Impairment Description

Sugarland Run (TMDL ID: VAN-A10R-01) was first listed as impaired in VADEQ's 2002 303(d) Total Maximum Daily Load Priority List and Report for not meeting the state's recreation water quality use standard due to exceedances of the fecal coliform bacteria criterion. In 2006, Sugarland Run was listed as impaired due to exceedances of the state's water quality criterion for *E. coli* bacteria. The impairment on Sugarland Run encompasses two assessment units (VAN-A10R_SUG01A00 and VAN-A10R_SUG01B06) and extends from the confluence of Folly Lick Branch, downstream to the confluence with the Potomac River. The combined length of both segments is 5.72 river miles.

Mine Run (TMDL ID: 60018) was first listed as impaired on Virginia's 2006 303(d) Total Maximum Daily Load Priority List due to exceedances of the state's water quality criteria for *E. coli* bacteria. The segment is 0.93 miles in length, beginning at the confluence with an unnamed tributary to Mine Run, approximately 0.5 river miles upstream from River Bend Road, and continuing downstream until the confluence with the Potomac River. The Assessment Unit for the impaired portion of Mine Run is VAN-A11R_MNR01A04.

Pimmit Run (TMDL ID: VAN-A12R-02) was first listed as impaired in VADEQ's 2002 303(d) Total Maximum Daily Load Priority List and Report for not meeting the state's recreation water quality use standard due to exceedances of the fecal coliform bacteria criterion. In 2010, Pimmit Run was listed as impaired due to exceedances of the state's water quality criterion for *E. coli* bacteria. The impairment on Pimmit Run encompasses three assessment units (VAN-A12R_PIM01A00, VAN-A12R_PIM02A00, and VAN-A12R_PIM02B06) and covers the entire length of the stream, from the headwaters of Pimmit Run, downstream to the confluence with the Potomac River.

Applicable Water Quality Standards

At the time of the initial listing of the Sugarland Run and Pimmit Run impairments, the Virginia Bacteria Water Quality Standard was expressed in terms of fecal coliform bacteria; however, the bacteria water quality standard changed and is now expressed in terms of *E. coli*. Virginia's bacteria water quality standard currently states that *E. coli* bacteria shall not exceed a geometric mean of 126 *E. coli* counts per 100 mL of water for four weekly samples taken within a calendar month. If there are insufficient data to calculate monthly geometric means in freshwater, no more than 10% of the total samples in the assessment period shall exceed 235 *E. coli* cfu/100 mL.

However, the loading rates for watershed-based modeling are available only in terms of the previous standard, fecal coliform bacteria. Therefore, the TMDL was expressed in *E. coli* by converting modeled daily fecal coliform concentrations to daily *E. coli* concentrations using an instream translator. This TMDL was required to meet both *E. coli* water quality criteria.

Watershed Characterization

The land use characterization for the Sugarland Run, Mine Run, and Pimmit Run watersheds was based on land cover data from the 2006 National Land Cover Database (NLCD). Dominant land uses in the watersheds are Developed (69%) and Forest (24%).

The potential sources of bacteria in the watershed were identified and characterized. Potential key sources of bacteria include run-off from point source dischargers, pet waste, residential waste, and wildlife sources.

Data obtained from the VADEQ's Northern Regional Office indicate that there is one individually permitted facility currently active within the Sugarland Run watershed (VAG406279) that is expected to discharge the contaminant of concern. The available flow data and water quality for this permitted facility was retrieved and analyzed. Average flows for the permitted facility were used in the HSPF model set-up and calibration. There are no VPDES permitted discharges in the Mine Run and Pimmit Run watersheds that are expected to discharge bacteria. In addition to VPDES permits, there are also seven MS4 (Municipal Separate Storm Sewer System) permits within the watersheds addressed by these TMDLs.

TMDL Technical Approach

The Hydrologic Simulation Program-Fortran (HSPF) model was selected and used as a tool to predict the instream water quality conditions of the delineated watersheds under varying scenarios of rainfall and fecal coliform loading. HSPF is a hydrologic, watershed-based water quality model. The results from the model were used to develop the TMDL allocations based on the existing fecal coliform loads. Basically, this means that HSPF can explicitly account for the specific watershed conditions, the seasonal variations in rainfall and climate conditions, and activities and uses related to fecal coliform loading.

The modeling process in HSPF starts with the following steps:

- delineating the watershed into smaller subwatersheds

- entering the physical data that describe each subwatershed and stream segment
- entering values for the rates and constants that describe the sources and the activities related to the fecal coliform loading in the watershed

The Sugarland Run, Mine Run, and Pimmit Run watersheds were delineated into 45 smaller subwatersheds to represent the watershed characteristics and to improve the accuracy of the HSPF model. This delineation was based on a Digital Elevation Model (DEM), stream reaches obtained from the National Hydrography Dataset (NHD), and stream flow and instream water quality data. Stream flow data were available from the U.S. Geological Survey (USGS). Weather data were obtained from the National Climatic Data Center (NCDC).

The period of 2002 to 2006 was used for HSPF hydrologic calibration and 2007 to 2010 was used to validate the HSPF model. The hydrologic calibration parameters were adjusted until there was good agreement between the observed and simulated stream flow, thereby indicating that the model parameterization is representative of the hydrologic characteristics of the watershed. The model results closely matched the observed flows during low flow conditions, base flow recession and storm peaks.

Instream water quality data for the calibration was retrieved from VADEQ, and was evaluated for potential use in the set-up, calibration, and validation of the water quality model. The existing *E. coli* loading was calculated based on current watershed conditions.

TMDL Calculations

The TMDL represents the maximum amount of a pollutant that the stream can receive without exceeding the water quality standard. The load allocation for the selected scenarios was calculated using the following equation:

$$\text{TMDL} = \sum \text{WLA} + \sum \text{LA} + \text{MOS}$$

Where,

WLA = wasteload allocation (point source contributions);

LA = load allocation (non-point source allocation); and

MOS = margin of safety.

The margin of safety (MOS) is a required component of the TMDL to account for any lack of knowledge concerning the relationship between effluent limitations and water quality. The MOS was implicitly incorporated in this TMDL. Implicitly incorporating the MOS required that allocation scenarios be designed to meet a calendar-month geometric mean *E. coli* criterion of 126 cfu/100 mL and the maximum assessment *E. coli* criterion of 235 cfu/100 mL with no more than a 10% exceedance rate.

Typically, there are several potential allocation strategies that would achieve the TMDL endpoint and water quality standards. A number of load allocation scenarios were developed to determine the final TMDL load allocation scenario. The goal of the TMDL scenarios was to target anthropogenic sources first.

Based on the load-allocation scenario analyses, the TMDL allocation plans that will meet the calendar-month *E. coli* geometric mean water quality criterion of 126 cfu/100 mL and the maximum assessment criterion for *E. coli* (235 cfu/100 mL) with no more than a 10% exceedance rate are presented in **Tables E-1** to **E-3**.

Table E-1: Sugarland Run Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Average *E. coli* Loads (cfu/yr)		Percent Reduction (%)
	Existing	Allocation	
Forest	2.53E+12	2.50E+12	1.0%
Cropland	7.36E+09	1.97E+08	97.3%
Pasture	1.19E+12	3.18E+10	97.3%
Urban/Non-MS4[1]	3.13E+13	8.38E+11	97.3%
Cattle - Direct Deposition	1.18E+11	0.00E+00	100.0%
Wildlife-Direct Deposition	3.99E+12	3.95E+12	1.0%
Failed Septics	8.91E+11	0.00E+00	100.0%
Permitted Point Source	1.74E+09	1.74E+09	0.0%
Future Growth[2]		1.21E+11	-
SSOs	7.77E+07	0.00E+00	100.0%
MS4s	1.74E+14	4.65E+12	97.3%
Total	**2.14E+14**	**1.21E+13**	94.4%

(1) The urban loads (non-MS4) include the load allocation (NPS loads) from high, medium, low intensity, and open space developed land use categories. It does not include bacteria load associated with MS4 areas.

(2) Future Growth allocation for point sources is calculated at 1 percent of the TMDL.

Table E-2: Mine Run Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Average *E. coli* Loads (cfu/yr)		Percent Reduction (%)
	Existing	Allocation	
Forest	3.39E+11	3.36E+11	1.0%
Cropland	8.82E+09	5.24E+08	94.1%
Pasture	9.63E+10	5.72E+09	94.1%
Urban/Non-MS4[1]	7.98E+12	4.74E+11	94.1%
Cattle - Direct Deposition	0.00E+00	0.00E+00	0.0%
Wildlife-Direct Deposition	2.21E+12	2.19E+12	1.0%
Failed Septics	2.21E+10	0.00E+00	100.0%
Future Growth[2]	0.00E+00	3.12E+10	-
SSOs	0.00E+00	0.00E+00	0.0%
MS4s	1.53E+12	9.12E+10	94.1%
Total	**1.22E+13**	**3.12E+12**	74.4%

(1) The urban loads (non-MS4) include the load allocation (NPS loads) the open space developed land use category. It does not include bacteria load associated with MS4 areas.

(2) There are no individual VPDES municipal point source dischargers. The Future Growth allocation for point sources is calculated at 1 percent of the TMDL.

Table E-3: Pimmit Run Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Average *E. coli* Loads (cfu/yr)		Percent Reduction (%)
	Existing	Allocation	
Forest	1.35E+12	1.33E+12	1.00%
Cropland	3.08E+09	1.80E+07	99.42%
Pasture	2.68E+11	1.57E+09	99.42%
Urban/Non-MS4[1]	4.90E+13	2.86E+11	99.42%
Cattle - Direct Deposition	0.00E+00	0.00E+00	0.00%
Wildlife-Direct Deposition	3.08E+12	3.05E+12	1.00%
Failed Septics	5.30E+11	0.00E+00	100.00%
Future Growth[2]	0.00E+00	5.85E+10	-
SSOs	1.28E+10	0.00E+00	100.0%
MS4s	1.91E+14	1.12E+12	99.42%
Total	**2.45E+14**	**5.85E+12**	97.6%

(1) The urban loads (non-MS4) include the load allocation (NPS loads) from the open space developed land use category. It does not include bacteria load associated with MS4 areas.

(2) There are no individual VPDES municipal point source dischargers. The Future Growth allocation for point sources is calculated at 1 percent of the TMDL.

The bacteria TMDLs for Sugarland Run (annual and daily loads) are presented in **Tables E-4** and **E-5**.

Table E-4: Sugarland Run Annual TMDL (cfu/year) for *E. coli*				
Watershed	**WLA[1]**	**LA**	**MOS**	**TMDL**
Sugarland Run	**4.78E+12**	**7.32E+12**	**Implicit**	**1.21E+13**
[1]Wasteload allocation includes allocated load for future growth of point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)				

Table E-5: Sugarland Run Daily TMDL (cfu/day) for *E. coli*				
Watershed	**WLA[1]**	**LA**	**MOS**	**TMDL**
Sugarland Run	**1.31E+10**	**7.72E+10**	**Implicit**	**9.03E+10**
[1]Wasteload allocation includes allocated load for future growth of point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)				

The bacteria TMDLs for Mine Run (annual and daily) are presented in **Tables E-6** and **E-7**.

Table E-6: Mine Run Annual TMDL (cfu/year) for *E. coli*				
Watershed	**WLA[1]**	**LA**	**MOS**	**TMDL**
Mine Run	**1.22E+11**	**3.00E+12**	**Implicit**	**3.12E+12**
[1]Wasteload allocation includes allocated load for future growth of point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)				

Table E-7: Mine Run Daily TMDL (cfu/day) for *E. coli*				
Watershed	**WLA[1]**	**LA**	**MOS**	**TMDL**
Mine Run	**3.35E+08**	**3.15E+10**	**Implicit**	**3.18E+10**
[1]Wasteload allocation includes allocated load for future growth of point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)				

The bacteria TMDLs for Pimmit Run (annual and daily) are presented in **Tables E-8** and **E-9**.

Table E-8: Pimmit Run Annual TMDL (cfu/year) for *E. coli*				
Watershed	**WLA[1]**	**LA**	**MOS**	**TMDL**
Pimmit Run	**1.17E+12**	**4.68E+12**	**Implicit**	**5.85E+12**
[1]Wasteload allocation includes allocated load for future growth of point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)				

Table E-9: Pimmit Run Daily TMDL (cfu/day) for *E. coli*				
Watershed	**WLA[1]**	**LA**	**MOS**	**TMDL**
Pimmit Run	**3.22E+09**	**4.56E+10**	**Implicit**	**4.88E+10**
[1]Wasteload allocation includes allocated load for future growth of point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)				

TMDL Implementation

Once a TMDL is approved by EPA, measures must be taken to reduce pollutant levels from both point and non-point sources. For non-point sources, the Commonwealth intends for reductions required for this TMDL to be implemented, and pollutant loading reductions achieved, through best management practices (BMPs). Permitted point sources of bacteria, including MS4 and VPDES permits will achieve any required reductions through incorporating the TMDL results into existing permits through their respective permit programs.

Implementation for both point and non-point sources will occur in stages. The benefits of staged implementation are: 1) as stream monitoring continues to occur, it allows for water quality improvements to be recorded as they are being achieved; 2) it provides a measure of quality control, given the uncertainties that exist in any model; 3) it provides a mechanism for developing public support; 4) it helps to ensure the most cost effective practices are implemented initially, and 5) it allows for the evaluation of the TMDL's adequacy in achieving the water quality standard.

A TMDL implementation plan will be developed that addresses, at a minimum, the requirements specified in the Code of Virginia, Section 62.1-44.19.7. State law directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters". The implementation plan "shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments." EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards.

As part of the Continuing Planning Process, VADEQ staff will present EPA-approved TMDLs and TMDL implementation plans to the State Water Control Board (SWCB) for inclusion in the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e) and Virginia's Public Participation Guidelines for Water Quality Management Planning. VADEQ staff will also request that the SWCB adopt TMDL WLAs as part of the Water Quality Management Planning Regulation (9VAC 25-720), except in those cases when permit limitations are equivalent to numeric criteria contained in the Virginia Water Quality Standards, such as in the case for bacteria discharges resulting from treatment of municipal and industrial wastewater.

Public Participation

Two public meetings were held during the development of this TMDL. Comments were received during the public comment period following each of the meetings and were addressed in this report.

1.0 Introduction

1.1 Regulatory Guidance

Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that do not meet water quality standards. TMDLs represent the total pollutant loading that a water body can receive without exceeding water quality standards. The TMDL process establishes the allowable loadings of pollutants for a water body based on the relationship between pollution sources and instream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and non-point sources to restore and maintain the quality of their water resources (EPA, 2001).

The Virginia Department of Environmental Quality (VADEQ) is the lead agency for the development of TMDLs statewide and focuses its efforts on all aspects of reduction and prevention of pollution to state waters. VADEQ works in coordination with the Virginia Department of Conservation and Recreation (DCR), the Virginia Department of Mines, Minerals, and Energy (DMME), and the Virginia Department of Health (VDH) to develop and regulate a more effective TMDL process. VADEQ ensures compliance with the Federal Clean Water Act and the Water Quality Planning Regulations, as well as with the Virginia Water Quality Monitoring, Information, and Restoration Act (WQMIRA), passed by the Virginia General Assembly in 1997, and coordinates public participation throughout the TMDL development process.

Within the context of the TMDL program, until recently a primary role of DCR was to regulate stormwater discharges from construction sites, and from municipal separate storm sewer systems (MS4s) through the Virginia Stormwater Management Program (VSMP). Effective July 1, 2013, these two stormwater regulatory programs are to be administered by DEQ, as well as the important role of initiating non-point source pollution control programs statewide through the use of federal grant money. DMME focuses its efforts on issuing surface mining permits and National Pollution Discharge Elimination System (NPDES) permits for industrial and mining operations. Lastly, VDH monitors waters for fecal coliform, classifies waters for shellfish growth and harvesting, and conducts surveys to determine sources of bacterial contamination (VADEQ, 2001).

As required by the Clean Water Act and WQMIRA, VADEQ develops and maintains a listing of all impaired waters in the state that details the pollutant(s) causing each impairment and the potential source(s) of each pollutant. This list is referred to as the 303(d) List of Impaired Waters (303 (d) List). In addition to 303(d) List development, WQMIRA directs VADEQ to develop and implement TMDLs for listed waters (VADEQ, 2004b). Once TMDLs have been developed, they are distributed for public comment and then submitted to the EPA for approval.

1.2 Impairment Listing

Segments of Sugarland Run, Mine Run and Pimmit Run were listed as impaired for bacteria on Virginia's 2010 303(d) Total Maximum Daily Load Priority List and Report due to exceedances of the state's water quality criterion for *E. coli* bacteria. The impaired segments are located in hydrologic units 02070008 and 02070010 and include portions of Fairfax, Loudoun, and Arlington Counties.

This report addresses six bacteria impaired segments for recreation uses within the Sugarland Run, Mine Run and Pimmit Run watersheds. All six impaired segments are riverine. Table **1-1** summarizes the details of the impaired segments and **Figure 1-1** presents their location. Descriptions of the impaired segments are presented below.

1.2.1 Sugarland Run

Sugarland Run (TMDL ID: VAN-A10R-01) was first listed as impaired in VADEQ's 2002 303(d) Total Maximum Daily Load Priority List and Report for not meeting the state's recreation water quality use standard due to exceedances of the fecal coliform bacteria criterion. In 2006, Sugarland Run was listed as impaired due to exceedances of the state's water quality criterion for *E. coli* bacteria. The impairment on Sugarland Run encompasses two assessment units (VAN-A10R_SUG01A00 and VAN-

A10R_SUG01B06) and extends from the confluence of Folly Lick Branch, downstream to the confluence with the Potomac River. The combined length of both segments is 5.72 rivermiles.

During the 2010 Water Quality Integrated Assessment period (January 1, 2003 – December 31, 2008), 5 out of 28 samples (17.9%) exceeded the maximum water quality assessment criterion (235 cfu/100 mL) for *E. coli* bacteria at Station 1aSUG004.42. Station 1aSUG004.42 is located at the Route 7 bridge crossing. The impaired portion of the Sugarland Run watershed is located in Fairfax County, Loudoun County, and the Town of Herndon.

1.2.2 Mine Run

Mine Run (TMDL ID: 60018) was first listed as impaired on Virginia's 2006 303(d) Total Maximum Daily Load Priority List due to exceedances of the state's water quality criteria for *E. coli* bacteria. The segment is 0.93 miles in length, beginning at the confluence with an unnamed tributary to Mine Run, approximately 0.5 rivermiles upstream from River Bend Road, and continuing downstream until the confluence with the Potomac River. The Assessment Unit for the impaired portion of Mine Run is VAN-A11R_MNR01A04.

During the 2010 Water Quality Integrated Assessment period (January 1, 2003 – December 31, 2008), 3 out of 12 samples (25%) exceeded the maximum water quality assessment criterion (235 cfu/100 mL) for *E. coli* bacteria at Station 1aMNR000.72. Station 1aMNR000.72 is located at the Route 603 bridge crossing. Mine Run is located in Fairfax County.

1.2.3 Pimmit Run

Pimmit Run (TMDL ID: VAN-A12R-02) was first listed as impaired in VADEQ's 2002 303(d) Total Maximum Daily Load Priority List and Report for not meeting the state's recreation water quality use standard due to exceedances of the fecal coliform bacteria criterion. In 2010, Pimmit Run was listed as impaired due to exceedances of the state's water quality criterion for *E. coli* bacteria.

The impairment on Pimmit Run encompasses three assessment units (VAN-A12R_PIM01A00, VAN-A12R_PIM02A00, and VAN-A12R_PIM02B06) and covers the entire length of the stream, from the headwaters of Pimmit Run, downstream to the confluence with the Potomac River. The combined length of all three segments is 7.37 rivermiles. The most downstream segment, VAN-A12R_PIM01A00, is 1.62 miles in length, beginning at the confluence with Little Pimmit Run, approximately 0.1 rivermiles downstream from Route 695, and continuing downstream until the confluence with the Potomac River. Segment VAN-A12R_PIM02A00, located just upstream, is 2.46 miles in length, beginning at the Route 309 bridge crossing at rivermile 4.16, and continuing downstream until the confluence with Little Pimmit Run, approximately 0.1 rivermiles downstream from Route 695. The most upstream segment, VAN-A12R_PIM02B06, is 3.29 miles in length, beginning at the headwaters of Pimmit Run, approximately 0.12 rivermile upstream from Route 7, and continuing downstream until the Route 309 bridge crossing, at rivermile 4.16.

During the 2010 Water Quality Integrated Assessment period (January 1, 2003 – December 31, 2008), 3 out of 11 samples (27.3%) at Station 1aPIM000.15; 3 out of 14 samples (21.4%) at Station 1aPIM001.89; and 4 out of 10 samples (40%) at Station 1aPIM004.16 exceeded the maximum water quality assessment criterion (235 cfu/100 mL) for *E. coli* bacteria. Station 1aPIM000.15 is located at the Route 120 (Glebe Road) bridge crossing. Station 1aPIM001.89 is located at the Ranleigh Road bridge crossing, and Station 1aPIM004.16 is located at the Route 309 bridge crossing. The Pimmit Run watershed is located in Fairfax and Arlington Counties.

Table 1-1. Impairment Summary for Sugarland Run, Mine Run and Pimmit Run

Cause Group Code ID	Assessment Unit	Stream Name	Length (miles)	Boundaries	Listing Station ID:	Impairment	Exceedance Rate*
A10R-01-BAC	VAN-A10R-01_SUG01A00	Sugarland Run	4.77	PWS designation area downstream until the confluence with the Potomac River	1aSUG004.42	*E. coli*	5/28 (18%)
	VAN-A10R-01_SUG01B06	Sugarland Run	0.95	Confluence of Folly Lick Branch downstream until the PWS designation area	1aSUG004.42	*E. coli*	5/28 (18%)
A11R-02-BAC	VAN-A11R_MNR01A04	Mine Run	0.93	Confluence of an unnamed tributary to Mine Run downstream until the confluence with the Potomac River	1AMNR000.72	*E. coli*	3/12 (25%)
A12R-02-BAC	VAN-A12R_PIM01A00	Pimmit Run	1.62	Confluence with Little Pimmit Run downstream until the confluence with the Potomac River.	1aPIM000.15	*E. coli*	3/11 (27.3%)
	VAN-A12R_PIM02A00	Pimmit Run	2.46	Route 309 bridge crossing downstream until confluence with Little Pimmit Run	1aPIM001.89	*E. coli*	3/14 (21.4%)
	VAN-A12R_PIM02B06	Pimmit Run	3.29	Headwaters of Pimmit Run, downstream until the Route 309 bridge crossing	1aPIM004.16	*E. coli*	4/10 (40%)

*Exceedance rate listed in Virginia's 2010 305(b)/303(d) Water Quality Integrated Assessment

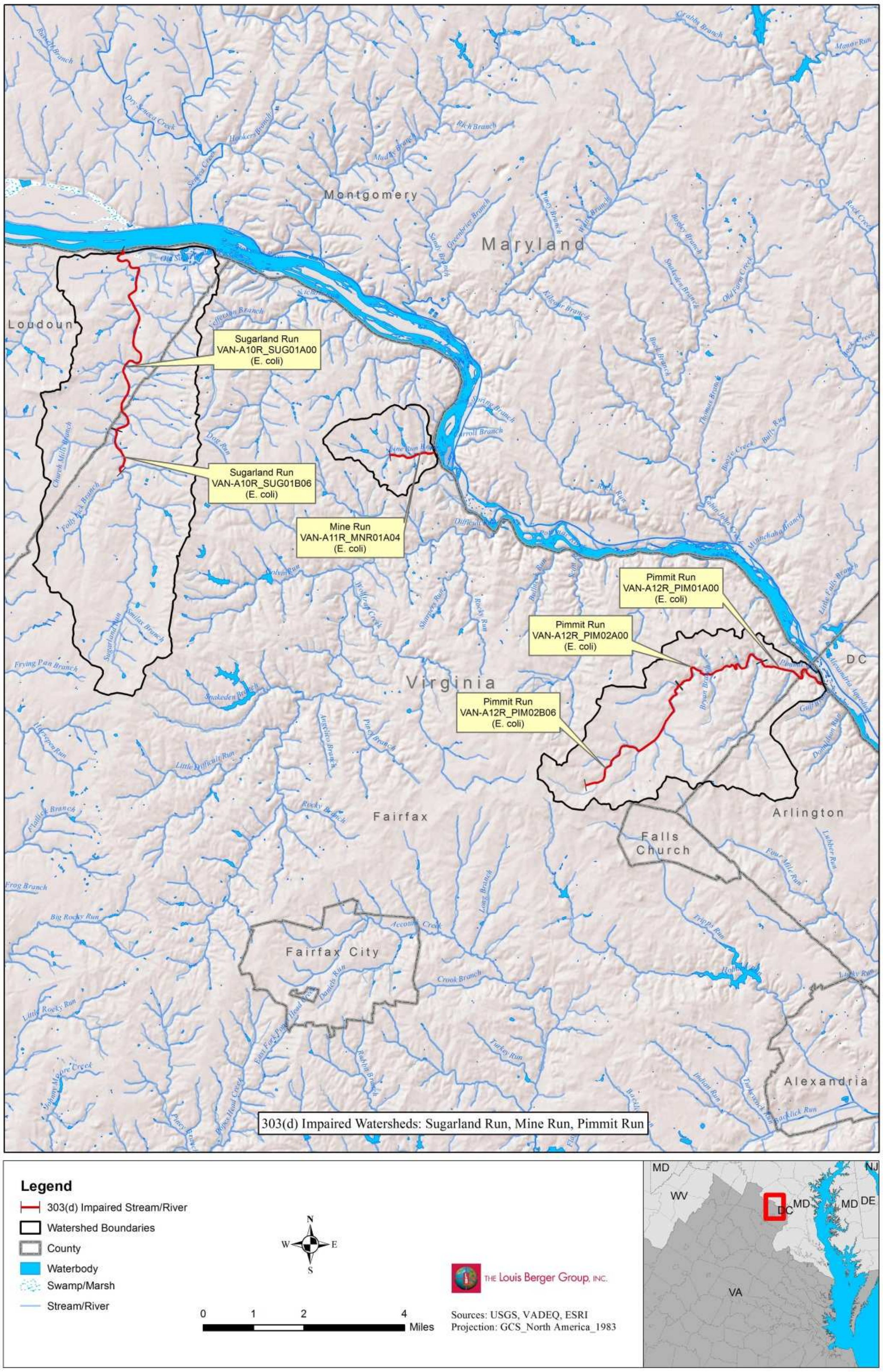


Figure 1-1: Location of the Bacteria Impairments on Sugarland Run, Mine Run and Pimmit Run.

1.3 Applicable Water Quality Standard

Water quality standards consist of designated uses for a waterbody and water quality criteria necessary to support those designated uses. According to Virginia Water Quality Standards (9 VAC 25-260-5), the term 'water quality standards' is defined as:

> *"…provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."*

1.3.1 Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10):

> *"All state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

1.3.2 Applicable Water Quality Criteria

According to Section 9 VAC 25-260-170.A of Virginia's Water Quality Standards (Effective January 6, 2011), for a non-shellfish, freshwater waterbody to be in compliance with Virginia bacteria standards for primary contact recreation, the current criteria are as follows:

> *"E. coli bacteria shall not exceed a monthly geometric mean of 126 CFU/100 ml in freshwater...Geometric means shall be calculated using all data collected during any calendar month with a minimum of four weekly samples… If there are insufficient data to calculate monthly geometric means in freshwater, no more*

than 10% of the total samples in the assessment period shall exceed 235 E. coli CFU/100 ml."

For bacteria TMDL development after January 15, 2003, *E. coli* is the primary applicable water quality target. However, the loading rates for watershed-based modeling are available only in terms of fecal coliform. Therefore, DCR, DEQ and EPA have agreed to apply a translator to instream fecal coliform data to determine whether reductions applied to the fecal coliform load would result in meeting instream *E. coli* criteria. The fecal coliform model and instream translator are used to calculate *E. coli* TMDLs (VADEQ, 2003). The following regression based instream translator is used to calculate *E. coli* concentrations from fecal coliform concentrations:

$$\log_2 EC\ (cfu/100mL) = -0.0172 + 0.91905 * \log_2 FC\ (cfu/100mL)$$

Where:
EC = *E. coli* bacteria concentration
FC = Fecal coliform bacteria concentration

The simulated daily fecal coliform concentrations are converted to daily *E. coli* concentrations using the instream translator. The TMDL development process must also account for seasonal and annual variations in precipitation, flow, land use, and pollutant contributions. Such an approach ensures that TMDLs, when implemented, do not result in exceedances under a wide variety of scenarios that affect bacteria loading.

1.4 TMDL Endpoint Identification

1.4.1 Selection of TMDL Endpoint and Water Quality Targets

One of the first steps in TMDL development is to determine a numeric endpoint, or water quality target, for each impaired segment. A water quality target compares the current stream conditions to the expected restored stream conditions after TMDL load reductions are implemented. Numeric endpoints for the bacteria impaired Sugarland Run, Mine Run and Pimmit Run TMDLs are established in Virginia Water Quality Standards (9 VAC 25-260). These standards state that all waters in Virginia should be free from any substances that can cause the water to exceed the state numeric criteria, interfere with its designated uses, or adversely affect human health and aquatic life. The current water quality target for non-shellfish waters, as stated in 9 VAC 25-260-170, is an *E. coli* geometric mean of no greater than 126 colony-forming units (cfu) per 100 mL for four or more weekly water quality samples taken during any calendar month. If insufficient data are available to calculate a geometric mean, the maximum assessment criterion (235 cfu per 100 mL) shall not be exceeded more than 10% of the time.

1.4.2 Critical Conditions

The critical condition refers to the “worst case scenario” of environmental conditions in the Sugarland Run, Mine Run, and Pimmit Run segments. Developing TMDLs to meet the water quality targets under the critical condition will ensure that the targets would also be met under all other conditions.

EPA regulations, 40 CFR 130.7 (c)(1), require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of Sugarland Run, Mine Run and Pimmit Run is protected during times when it is most vulnerable. Critical conditions are important because they describe the combination of factors that cause an exceedance of water quality criteria. They will help in identifying the actions that may have to be undertaken to meet water quality standards.

1.4.2.1 Sugarland Run

The dominant land uses in the Sugarland Run watershed are developed (74%) and forest (18%). Potential key sources of *E. coli* include run-off from residential areas and wildlife sources.

E. coli loadings result from sources that can contribute during wet weather and dry weather. The critical conditions were determined from the available instream water quality data and flow data obtained from a nearby USGS flow monitoring station.

The following figure shows the observed level of *E. coli* (**Figure 1-2**) under different flow conditions at VADEQ water quality station 1aSUG004.42. The data for flow was obtained from USGS station 01646000 (Difficult Run near Great Falls, VA), located on

Difficult Run before the confluence with the Potomac River. **Figure 1-2** depicts *E. coli* concentrations recorded between 2002 and 2010 with the available corresponding stream flow percentile.

E. coli data were available only at VADEQ listing station 1aSUG004.42. The maximum assessment criterion for *E. coli* is shown as a thick red line (235 cfu/100 mL of water). Plotting *E. coli* data along with available stream flow data (**Figure 1-2**) revealed that exceedances of the bacteria criteria occurred during all flow conditions except for low flow.

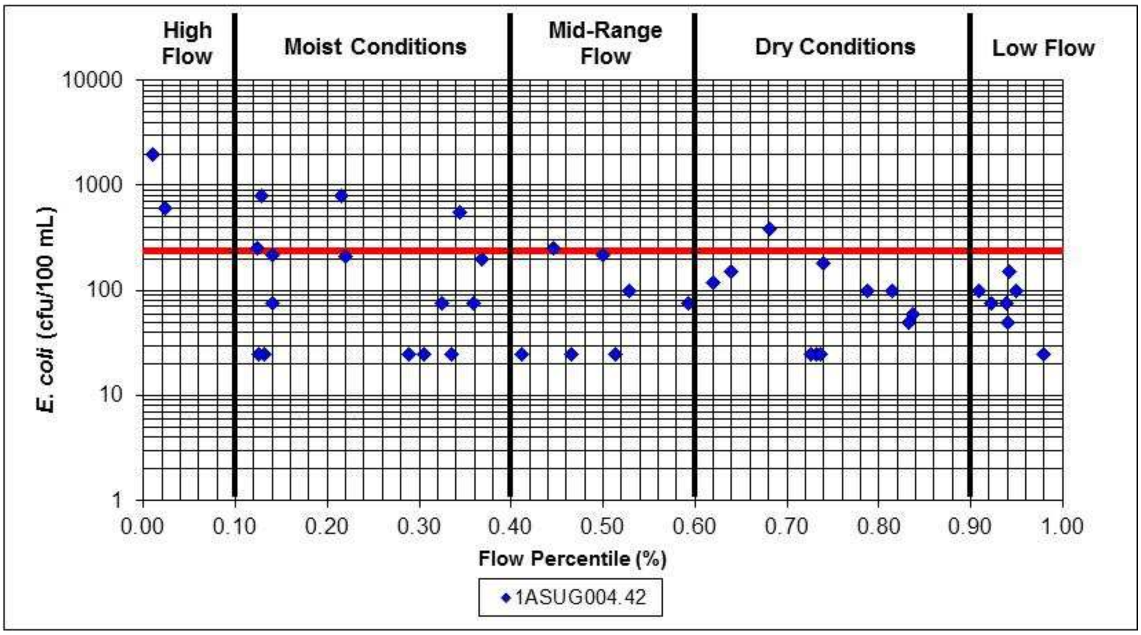


Figure 1-2: Flow Percentile and *E. coli* Concentrations for Sugarland Run at 1aSUG004.42 (2002-2010).

In order to be protective of the water quality standard, both high and low flow periods were considered as the critical conditions. Exceedances under high-flow conditions would occur from indirect (runoff-based) sources of bacteria, and would most likely exceed the maximum assessment criterion. Bacteria loads under low-flow conditions would likely occur from point sources or direct depositional sources of bacteria, and would most likely exceed the both the maximum assessment and the geometric mean criteria.

The TMDL is required to meet both the geometric mean criterion and have no more than 10% exceedances of the maximum assessment bacteria criterion. Therefore, it is necessary for the critical condition to consider both wet weather, high flow conditions and dry weather, low flow conditions in order to comply with both bacteria criteria.

1.4.2.2 Mine Run

The dominant land uses in the Mine Run watershed are forest (55%) and developed (35%). Potential key sources of *E. coli* include run-off from residential and wildlife sources.

E. coli loadings result from sources that can contribute during wet weather and dry weather. The critical conditions were determined from the available instream water quality data and flow data obtained from a nearby USGS flow monitoring station.

The following figure shows the observed level of *E. coli* (**Figure 1-3**) under different flow conditions at VADEQ water quality station 1aMNR000.72. The data for flow was obtained from USGS station 01646000 (Difficult Run near Great Falls, VA), located on Difficult Run before the confluence with the Potomac River. **Figure 1-3** depicts *E. coli* concentrations recorded between 2003 and 2010 with the available corresponding stream flow percentile.

E. coli data were available only at VADEQ listing station 1aMNR000.72. The maximum assessment criterion for *E. coli* is shown as a thick red line (235 cfu/100 mL of water). Plotting *E. coli* data along with available stream flow data (**Figure 1-3**) revealed that the majority of the exceedances occurred during mid-range flow to high flow conditions.

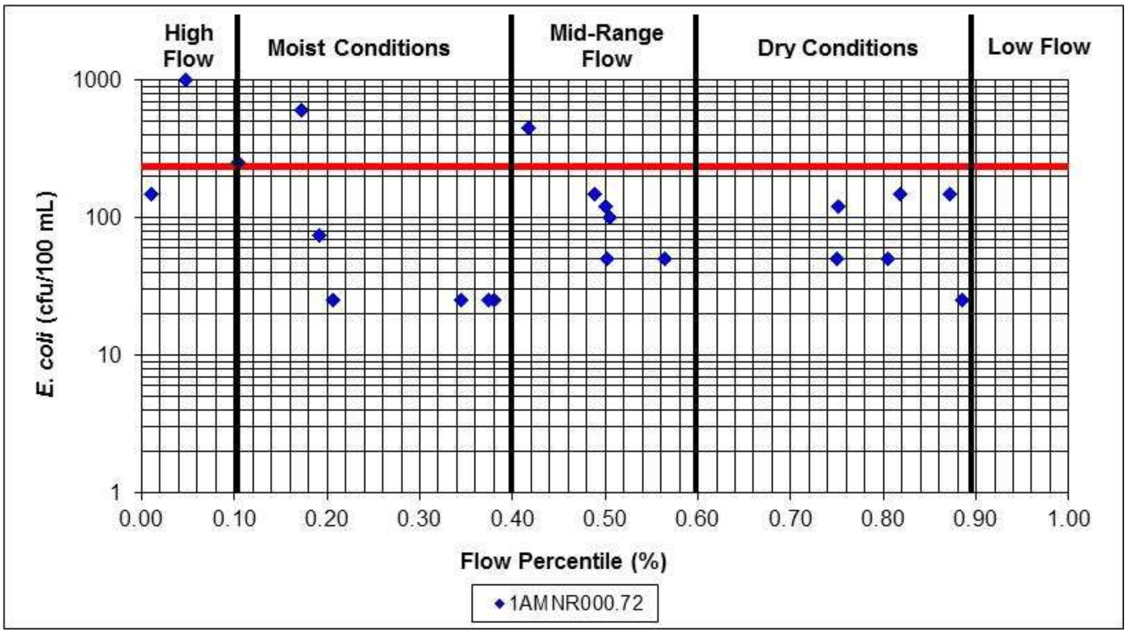


Figure 1-3: Flow Percentile and *E. coli* Concentrations for Mine Run at 1aMNR000.72 (2003-2010).

In order to be protective of the water quality standard, both high and low flow periods were considered as the critical conditions. Exceedances under high-flow conditions would occur from indirect sources of bacteria, and would most likely exceed the maximum assessment criterion. Bacteria loads under low-flow conditions would likely occur from direct sources of bacteria, and would most likely exceed both criteria.

The TMDL is required to meet both the geometric mean and maximum assessment bacteria criteria. Therefore, it is necessary for the critical condition to consider both wet weather, high flow conditions and dry weather, low flow conditions in order to comply with both bacteria criteria.

1.4.2.3 Pimmit Run

The dominant land uses in the Pimmit Run watershed are developed (67%) and forest (29%). Potential key sources of *E. coli* include run-off from residential and wildlife sources.

E. coli loadings result from sources that can contribute during wet weather and dry weather. The critical conditions were determined from the available instream water quality data and flow data obtained from a nearby USGS flow monitoring station.

The following figure shows the observed levels of *E. coli* (**Figure 1-4**) under different flow conditions at VADEQ water quality stations 1aLIO000.15, 1aLIO001.50, 1aPIM000.15, 1aPIM001.89, 1aPIM001.76 and 1aPIM004.16. The data for flow was obtained from USGS station 01646000 (Difficult Run near Great Falls, VA), located on Difficult Run before the confluence with the Potomac River. **Figure 1-4** depicts *E. coli* concentrations recorded between 2005 and 2010 with the available corresponding stream flow percentile.

E. coli data were available at VADEQ listing stations 1aLIO000.15, 1aLIO001.50, 1aPIM000.15, 1aPIM001.76, 1aPIM001.89, and 1aPIM004.16. The maximum assessment criterion for *E. coli* is shown as a thick red line (235 cfu/100 mL of water). Plotting *E. coli* data along with available stream flow data (**Figure 1-4**) revealed that the exceedances occurred during all flow conditions except low flow.

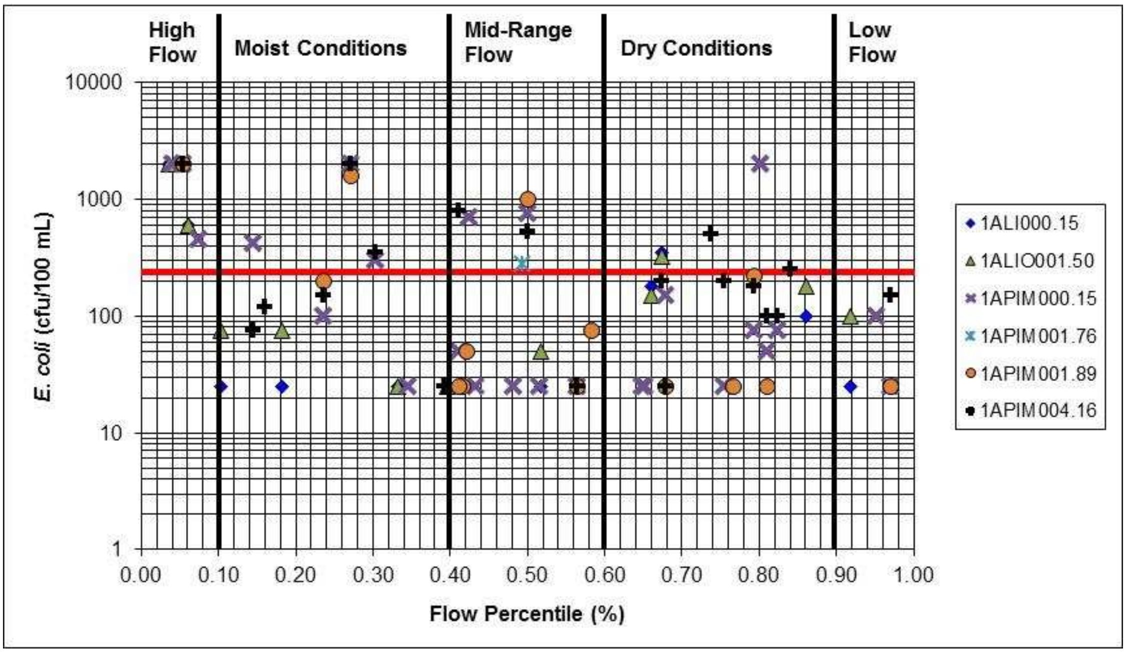


Figure 1-4: Flow Percentile and *E. coli* Concentrations for Pimmit Run at 1aLIO000.15, 1aLIO001.50, 1aPIM000.15, 1aPIM001.76, 1aPIM001.89 and 1aPIM004.16 (2005-2010).

In order to be protective of the water quality standard, both high and low flow periods were considered as the critical conditions. Exceedances under high-flow conditions would occur from indirect (runoff-based) sources of bacteria, and would most likely exceed the maximum assessment criterion. Bacteria loads under low-flow conditions would likely occur from point sources or direct depositional sources of bacteria, and would most likely exceed the both the maximum assessment and the geometric mean criteria.

The TMDL is required to meet both the geometric mean and maximum assessment bacteria criteria. Therefore, it is necessary for the critical condition to consider both wet weather, high flow conditions and dry weather, low flow conditions in order to comply with both criteria.

1.5 Consideration of Seasonal Variations

Seasonal variations involve changes in stream flow and water quality because of hydrologic and climatologic patterns. Seasonal variations were explicitly included in the modeling approach for this TMDL. The continuous simulation model developed for this TMDL explicitly incorporates the seasonal variations of rainfall, runoff and fecal coliform wash-off by using an hourly time-step. In addition, fecal coliform accumulation rates for each land use were developed on a monthly basis. This allowed for the consideration of temporal variability in fecal coliform loading within the watershed.

2.0 Watershed Description and Source Assessment

In this section, the types of data available and information collected for the development of TMDLs for the bacteria impaired segments of the Sugarland Run, Mine Run and Pimmit Run watershed are presented. This information was used to characterize the waterbodies and their watersheds and to inventory and identify potential point and non-point sources of bacteria in the watershed.

2.1 Data and Information Inventory

A wide range of data and information were used in the development of these TMDLs. Categories of data that were used include the following:

(1) Physiographic data that describe physical conditions (i.e., topography, soils, and land use) within the watershed.

(2) Hydrographic data that describe the stream networks and reaches.

(3) Data related to uses of the watershed and other activities in the basin that can be used in the identification of potential *E. coli* sources.

Table 2-1 shows the various data types and the data sources used in TMDL development.

Table 2-1: Inventory of Data and Information Used in TMDL Development

Data Category	Description	Source(s)
Watershed physiographic data	Watershed boundary	USGS HUC Boundaries (2007)
	Land use/land cover	NOAA (2006)
	Soil data (*Soil Survey Geographic Database* via *Soil Data Mart*)	USDA-NRCS (2010a)
	Topographic data (USGS-30 meter DEM)	USDA-NRCS (2010b)
Hydrographic data	Stream network and reaches (1:24k scale) – National Hydrography Dataset	USGS (2008)
Weather data	Information, data, reports, and maps that can be used to support bacteria source identification and loading	NCDC (2011)
Watershed activities/uses data and information related to bacteria production	Livestock inventory	Census of Agriculture (2007), Loudoun County (2011), Arlington County (2011), Loudoun County SWCD (2011)
	Wildlife inventory	Difficult Run Bacteria TMDL (2008), VA DGIF (2011)
	Septic systems inventory and failure rates	VA DEQ, Census Bureau, Loudoun County (2011), Fairfax County (2011), Arlington County (2011)
	Pet estimates	AVMA (2007)
Point sources and direct discharge data and information	Permitted facilities locations and discharge monitoring reports (DMRs)	VA DEQ (2011b)
	MS4 permits	VA DCR (2011b)
	SSO data and locations	VA DEQ (2011b)
Environmental monitoring data	Monitoring data (bacteria water quality) and station locations	VA DEQ (2011b)
	Stream flow data	USGS (2011)

Notes:
AVMA: American Veterinary Medical Association
HUC: Hydrologic Unit Code
NCDC: National Climatic Data Center
NHD: National Hydrography Dataset
NLCD: National Land Coverage Data
NOAA: National Oceanic and Atmospheric Association
NRCS: Natural Resources Conservation Service
SWCD: Soil and Water Conservation District
USGS: U.S. Geological Survey
VA DCR: Virginia Department of Conservation and Recreation
VA DEQ: Virginia Department of Environmental Quality
VA DGIF: Virginia Department of Game and Inland Fisheries

The following agencies were specifically contacted to obtain population estimates for wildlife, livestock, and septic systems/straight pipes:

- Loudoun County Soil and Water Conservation District
- Northern Virginia Soil and Water Conservation District
- Virginia Cooperative Extension Office – Loudoun
- Virginia Cooperative Extension Office – Fairfax
- Virginia Cooperative Extension Office – Arlington
- Loudoun County Health Department
- Fairfax County Health Department
- Arlington County Department of Environmental Services
- Virginia Department of Game and Inland Fisheries

2.2 Watershed Descriptions and Identification

The streams addressed in this TMDL include Sugarland Run, Mine Run, and Pimmit Run. These watersheds occupy a combined drainage area of 37 square miles.

2.2.1 Location

All impaired segment watersheds are located in Northern Virginia. Sugarland Run and Mine Run are located in USGS Cataloging Unit 02070008. Pimmit Run is located in USGS Cataloging Unit 02070010. Watershed drainage areas and major roads within each watershed are described below.

2.2.1.1 Sugarland Run

Sugarland Run is located in Loudoun and Fairfax Counties and occupies a drainage area of 22.7 square miles. Approximately 8.9 square miles of the watershed are in Loudoun County and 13.8 square miles are in Fairfax County. The Town of Herndon is also located in the Sugarland Run watershed. As shown in **Figure 2-1**, the major roadways that run through the watershed are State Highways 228, 606, 267, 7, 637, 286 and 602. State Highway 228 runs north and south through the middle of the watershed. State Highway 7 runs diagonally across the center of the watershed. State Highways 267 and 606 run east and west across the southern portion of the watershed. State Highways 606, 637, and 286 intersect the western portions of the watershed. And State Highway 602 runs along the eastern edge of the watershed.

2.2.1.2 Mine Run

Mine Run is located in Fairfax County and occupies a drainage area of 2.5 square miles. As shown in **Figure 2-1**, the major roadways that run through the watershed are State Highways 681, 193, and 603. State Highway 603 runs north and south through the eastern half of the watershed. State highways 681 and 193 run along the southwestern edge of the watershed.

2.2.1.3 Pimmit Run

Pimmit Run is located in Fairfax and Arlington Counties and has a drainage area of 12.2 square miles. 10.1 square miles of the watershed are in Fairfax County, and 2.1 square miles are in Arlington County. As shown in **Figure 2-1**, the major roadways that run through the watershed are Interstates I-66, I-495 and State Highways 123, 267, 309, 120, and 7. Interstates I-66 and I-495 run across the southwestern corner of the watershed. State Highway 123 runs along the northern boundary of the watershed. State Highway 267 runs north and south through the western portion of the watershed. State Highway 7 runs diagonally across the western edge of the watershed. And State Highway 309 runs diagonally across the center of the watershed.

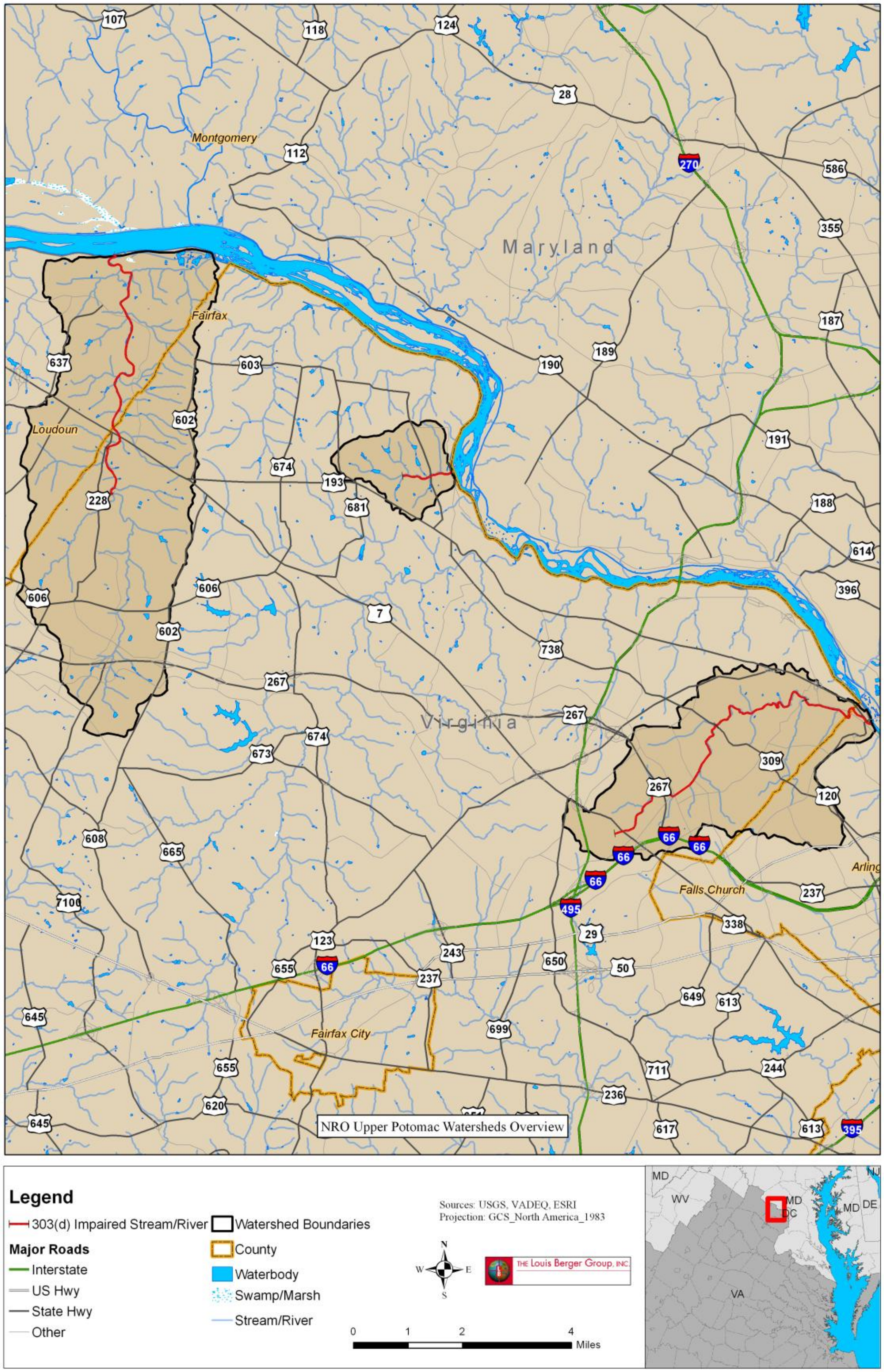


Figure 2-1: Map of the Sugarland Run, Mine Run, and Pimmit Run Watersheds

2.2.2 Topography

A digital elevation model (DEM) based on USGS National Elevation Dataset (NED) was used to characterize topography in the watershed. NED data were obtained from the Geospatial Data Gateway system maintained by the USDA Natural Resources Conservation Service. Elevation within the Sugarland Run watershed ranges from 177 to 474 feet above mean sea level. Elevation within the Mine Run watershed ranges from 144 to 377 feet above mean sea level. Elevation within the Pimmit Run watershed ranges from 0 to 494 feet above mean sea level.

2.2.3 Soils Types and Hydrologic Soil Groups

The following section details soil type and hydrologic group for the Sugarland Run, Mine Run, and Pimmit Run watersheds. The soil type characterization is based on data obtained from the Soil Survey Geographic (SSURGO) Database via *Soil Data Mart*, a USGS-approved program and multi-purpose environmental analysis system integrating GIS, national watershed data, and environmental assessment and modeling tools.

The hydrologic soil groups represent different levels of infiltration capacity of the soils. Hydrologic soil group “A” designates soils that are well- to excessively well-drained, whereas hydrologic soil group “D” designates soils that are poorly drained. This means that soils in hydrologic group “A” allow a larger portion of the rainfall to infiltrate and become part of the ground water system. On the other hand, compared to the soils in hydrologic group “A,” soils in hydrologic group “D” allow a smaller portion of the rainfall to infiltrate and become part of the ground water. Consequently, more rainfall becomes part of the surface water runoff. Descriptions of the hydrologic soil groups are presented in **Table 2-2**.

Table 2-2: Descriptions of Hydrologic Soil Groups	
Hydrologic Soil Group	**Description**
A	High infiltration rates. Soils are deep, well-drained to excessively drained sand and gravels.
B	Moderate infiltration rates. Deep and moderately deep, moderately well- and well-drained soils with moderately coarse textures.
B/D	Combination of Hydrologic Soils Groups B and D, where drained areas are of Soil Group B and undrained areas are of Group D.
C	Moderate to slow infiltration rates. Soils with layers impeding downward movement of water or soils with moderately fine or fine textures.
C/D	Combination of Hydrologic Soil Groups C and D, where drained areas are of Soil Group C and undrained areas are of Group D.
D	Very slow infiltration rates. Soils are clayey, have high water table, or shallow to an impervious cover.

Distribution of the hydrologic groups within the TMDL watersheds is presented in **Table 2-3**. The category "NA" in the hydrologic soil group breakdown refers to those classes defined as water, urban land, and rock outcrops. The dominant soil types in the TMDL watersheds are Glenelg, disturbed soils such as Urban Land, and Penn.

2.2.3.1 Sugarland Run

The major hydrologic soil groups within the Sugarland Run watershed are designated as NA (ie. to those classes defined as water, urban land and rock outcrops - 52%) and Group D (38%) (**Table 2-3**). The dominant soil types within the watershed are disturbed soils such as urban land (19%), followed by Penn (14%), which are deep, well-drained and found on nearly level to steep moderately dissected uplands; and Glenelg (9%), which are very deep, well drained soils found on nearly level to very steep soils in well dissected uplands (NRCS).

2.2.3.2 Mine Run

The major hydrologic groups within the Mine Run watershed are Group D (49%) and Group B (48%) (**Table 2-3**). The dominant soil types within the watershed are Glenelg (74%), described above; and Meadowville (9%), which are very deep and moderately well to well drained found on undulating to rolling uplands (NRCS).

2.2.3.3 Pimmit Run

The major hydrologic groups within the Pimmit Run watershed are Group D (58%), and Group NA (21%) (**Table 2-3**). The dominant soil types within the watershed are Glenelg (50%), described above; disturbed soils such as urban land (25%); and Meadowville (6%), described above.

Table 2-3: Distribution of Hydrologic Soil Groups within the Sugarland Run, Mine Run, and Pimmit Run Watersheds

	Sugarland Run		Mine Run		Pimmit Run	
Soil Hydrologic Group	**Acres**	**Percent of Watershed**	**Acres**	**Percent of Watershed**	**Acres**	**Percent of Watershed**
A	-	-	-	-	-	-
B	738	5%	769	48%	1,177	15%
B/D	-	-	-	-	1	0%
C	570	4%	11	1%	464	6%
C/D	119	1%	-	-	-	-
D	5,559	38%	773	49%	4,570	58%
NA*	7,522	52%	37	2%	1,616	21%
TOTAL	**14,508**	**100%**	**1,590**	**100%**	**7,828**	**100%**

*The category "NA" in the hydrologic group breakdown refers to those classes defined as water, urban land and rock outcrops.

2.2.4 Land Use

The land use characterization for the Sugarland Run, Mine Run, and Pimmit Run watersheds was based on the latest available land cover data from the National Land Cover Dataset, also known as NLCD 2006 Land Use Dataset. The distribution of land uses in the watershed, by land area and percentage, are presented in **Table 2-4**. Descriptions of the land use categories are presented in **Table 2-5**. Dominant land uses in the watersheds are Developed (69%) and Forest (24%). **Figure 2-2** depicts the land use distribution within the TMDL watersheds.

Table 2-4: Land Use Distribution in the Sugarland Run, Mine Run, and Pimmit Run Watersheds

General Land Use Category	Specific Land Use Type	Sugarland Run				Mine Run				Pimmit Run			
		Acres*	Total Acres	% of Watershed	Total Percent	Acres*	Total Acres	% of Watershed	Total Percent	Acres*	Total Acres	% of Watershed	Total Percent
Developed	Developed High Intensity	848	10,796	6%	74%	2	551	<1%	35%	201	5,236	3%	67%
	Developed Medium Intensity	2,935		20%		9		1%		832		11%	
	Developed Low Intensity	4,984		34%		80		5%		3,059		39%	
	Developed Open Space	2,029		14%		461		29%		1,144		15%	
Agricultural	Cultivated Crops	58	147	<1%	1%	18	32	1%	2%	15	35	0%	0%
	Pasture/Hay	89		1%		15		1%		20		0%	
Forest	Deciduous Forest	2,210	2,578	15%	18%	800	874	50%	55%	1,815	2,233	23%	29%
	Evergreen Forest	164		1%		29		2%		156		2%	
	Mixed Forest	204		1%		45		3%		262		3%	
Wetland	Palustrine Emergent Wetland	10	599	<1%	4%	2	28	<1%	2%	2	236	0%	3%
	Palustrine Forested Wetland	556		4%		22		1%		228		3%	
	Palustrine Scrub/Shrub Wetland	34		<1%		4		<1%		7		0%	
Water	Open Water	44	44	<1%	<1%	10	10	1%	1%	-		-	-
Other	Scrub/Shrub	243	345	2%	2%	85	95	5%	6%	78	89	1%	1%
	Grassland/Herbaceous	93		1%		10		1%		9		0%	
	Unconsolidated Shore	2		<1%		-		-		-		-	
	Bare Land	8		<1%		-		-		1		0%	
Total*		**14,509**		**100%**		**1,590**		**100%**		**7,828**		**100%**	

***Differences in totals due to rounding**

Table 2-5: Descriptions of Land Use Types

Land Use Type	Description
Developed, High Intensity	Includes highly developed areas where people reside or work in high numbers. Impervious surfaces account for 80 to 100 percent of the total cover.
Developed, Medium Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 to 79 percent of the total cover.
Developed, Low Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 21 to 49 percent of total cover.
Developed Open Space	Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover.
Cultivated Crops	Areas used for the production of annual crops. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle and not tilled. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.
Deciduous Forest	Areas dominated by trees generally greater than 5 meters tall and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest	Areas dominated by trees generally greater than 5 meters tall and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest	Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.
Palustrine Emergent Wetland	Includes all tidal and non-tidal wetlands dominated by persistent emergent vascular plants, emergent mosses or lichens, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Plants generally remain standing until the next growing season. Total vegetation cover is greater than 80 percent.
Palustrine Forested Wetland	Includes all tidal and non-tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Total vegetation coverage is greater than 20 percent.
Palustrine Scrub/Shrub Wetland	Includes all tidal and non tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Total vegetation coverage is greater than 20 percent. The species present could be true shrubs, young trees and shrubs, or trees that are small or stunted due to environmental conditions (Cowardin et al. 1979).
Open Water	All areas of open water, generally with less than 25 percent cover of vegetation or soil.
Scrub/Shrub	Areas dominated by shrubs less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes tree shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.
Grassland/Herbaceous	Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Unconsolidated Shore	Unconsolidated material such as silt, sand, or gravel that is subject to inundation and redistribution due to the action of water. Characterized by substrates lacking vegetation except for pioneering plants that become established during brief periods when growing conditions are favorable. Erosion and deposition by waves and currents produce a number of landforms representing this class.
Bare Land	Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earth material. Generally, vegetation accounts for less than 10 percent of total cover.

Source: Coastal NLCD Classification Scheme, NOAA Coastal Services Center

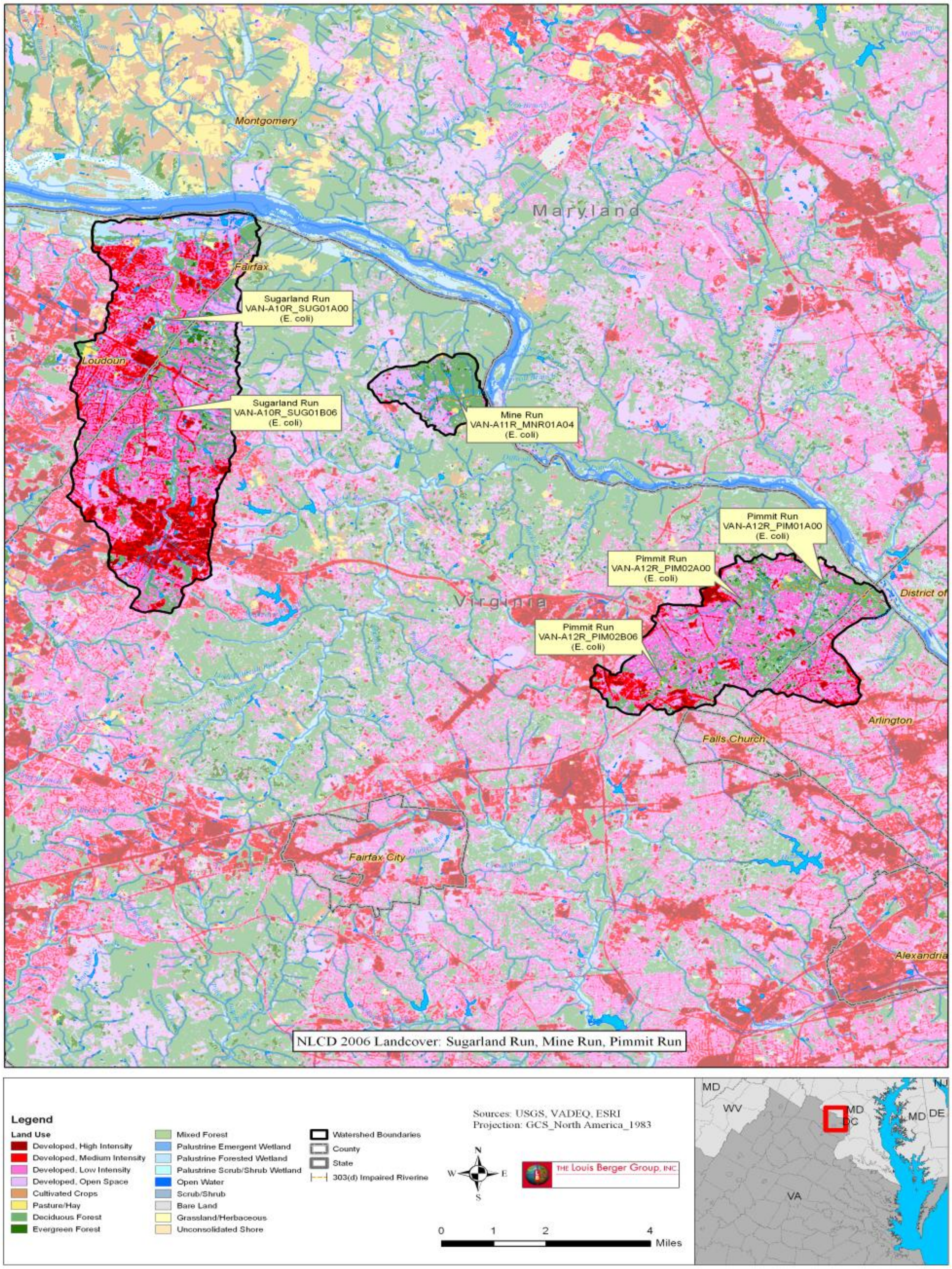


Figure 2-2: Land Use for the Sugarland Run, Mine Run, and Pimmit Run Watersheds

2.3 Stream Flow Data

Historical stream flow data were only available from three USGS stream flow-gauging stations within the Sugarland Run watershed. All available data were measured between 1966 and 1982. Information regarding the data collected at these stations is shown in **Table 2-6**. USGS gauging stations 01644295, 01644291, and 01644290 are located upstream of the impaired segment in the headwaters of the Sugarland Run watershed. Locations of the USGS stations are shown in **Figure 2-3**. No present or historical USGS stream flow-gauging stations are located in the Mine Run or Pimmit Run watersheds.

Table 2-6: USGS Flow Gauges in the Sugarland Run Watershed

Station	Site Name	Period of Daily-Mean Data	
		Start Date	End Date
01644295	SMILAX BRANCH AT RESTON, VA	3/1/1967	9/30/1978
01644291	STAVE RUN NEAR RESTON, VA	10/1/1971	4/17/1982
01644290	STAVE RUN AT RESTON, VA	12/1/1966	2/7/1973

2.4 Ambient Water Quality Data for Bacteria

Environmental monitoring efforts for collecting bacteria data in the TMDL watersheds have been conducted by the Virginia Department of Environmental Quality (VADEQ). All available bacteria data for streams located within the TMDL watersheds were analyzed and compared to VADEQ water quality criteria for bacteria. **Table 2-7** summarizes VADEQ monitoring efforts within the impaired watersheds for all bacteria indicators according to station ID.

Table 2-7: Summary of Instream Monitoring for Bacteria

Station ID	Stream	Indicator	Number of Samples	Sample Date		Minimum[1,2]	Maximum[1,2]
				First	Last		
1ASUG004.42	Sugarland Run	Fecal Coliform	50	12/2/1998	11/3/2010	28	8000
		E. coli	42	5/28/2002	11/3/2010	25	2000
1AMNR000.72	Mine Run	Fecal Coliform	0	-	-	-	-
		E. coli	21	8/7/2003	10/18/2010	25	1000
1APIM000.15	Pimmit Run	Fecal Coliform	41	11/17/1998	9/21/2010	25	4000
		E. coli	25	1/30/2008	9/21/2010	25	2000
1APIM001.76	Pimmit Run	Fecal Coliform	0	-	-	-	-
		E. coli	1	8/11/2005	8/11/2005	280	280
1APIM001.89	Pimmit Run	Fecal Coliform	10	3/18/2008	12/16/2008	25	2000
		E. coli	14	12/1/2005	12/16/2008	25	2000
1APIM004.16	Pimmit Run	Fecal Coliform	19	12/2/1998	12/16/2008	25	8000
		E. coli	19	3/18/2008	10/18/2010	25	2000
1ALIO000.15	Little Pimmit Run[3]	Fecal Coliform	0	-	-	-	-
		E. coli	11	2/2/2009	11/4/2010	25	2000
1ALIO001.50	Little Pimmit Run[3]	Fecal Coliform	0	-	-	-	-
		E. coli	11	2/2/2009	11/4/2010	25	2000

[1] Units for Fecal Coliform: MPN/100 ml
[2] Units for E. coli: CFU/100 ml
[3] Little Pimmit Run is a tributary to Pimmit Run.

Table 2-8 shows the total number and percentage of samples exceeding the water quality maximum assessment criterion of 235 cfu/100 mL for *E. coli* during the 2010 Integrated Assessment Period (January 1, 2003 to December 31, 2008). **Figure 2-3** presents the location of VADEQ's water quality monitoring stations within the Sugarland Run, Mine Run and Pimmit Run.

Table 2-8: Summary of VADEQ *E. coli* Exceedances for Sugarland Run, Mine Run, and Pimmit Run

Station ID	Stream	Cause	Exceedance Rate*
1ASUG004.42	Sugarland Run	*E. coli*	5/28 (18%)
1AMNR000.72	Mine Run	*E. coli*	3/12 (25%)
1APIM000.15	Pimmit Run	*E. coli*	3/11 (27.3%)
1APIM001.89	Pimmit Run	*E. coli*	3/14 (21.4%)
1APIM004.16	Pimmit Run	*E. coli*	4/10 (40%)

*Exceedance rate listed in Virginia's 2010 305(b)/303(d) Water Quality Integrated Assessment

2.4.1 Citizen Monitoring Data

Bacteria Coliscan data was collected at five stations throughout the Little Pimmit Run watershed by the “Save Little Pimmit Run” group in 2008. The data collected by this group indicated that there was a high probability that a bacteria impairment existed in Little Pimmit Run. Because of the efforts of this group, DEQ followed up with monitoring in Little Pimmit Run in 2009 and 2010 and confirmed that there was a bacteria impairment (*Note: In the DRAFT 2012 Integrated Assessment Little Pimmit Run has been listed as not supporting the recreation use due to E. coli bacteria*).

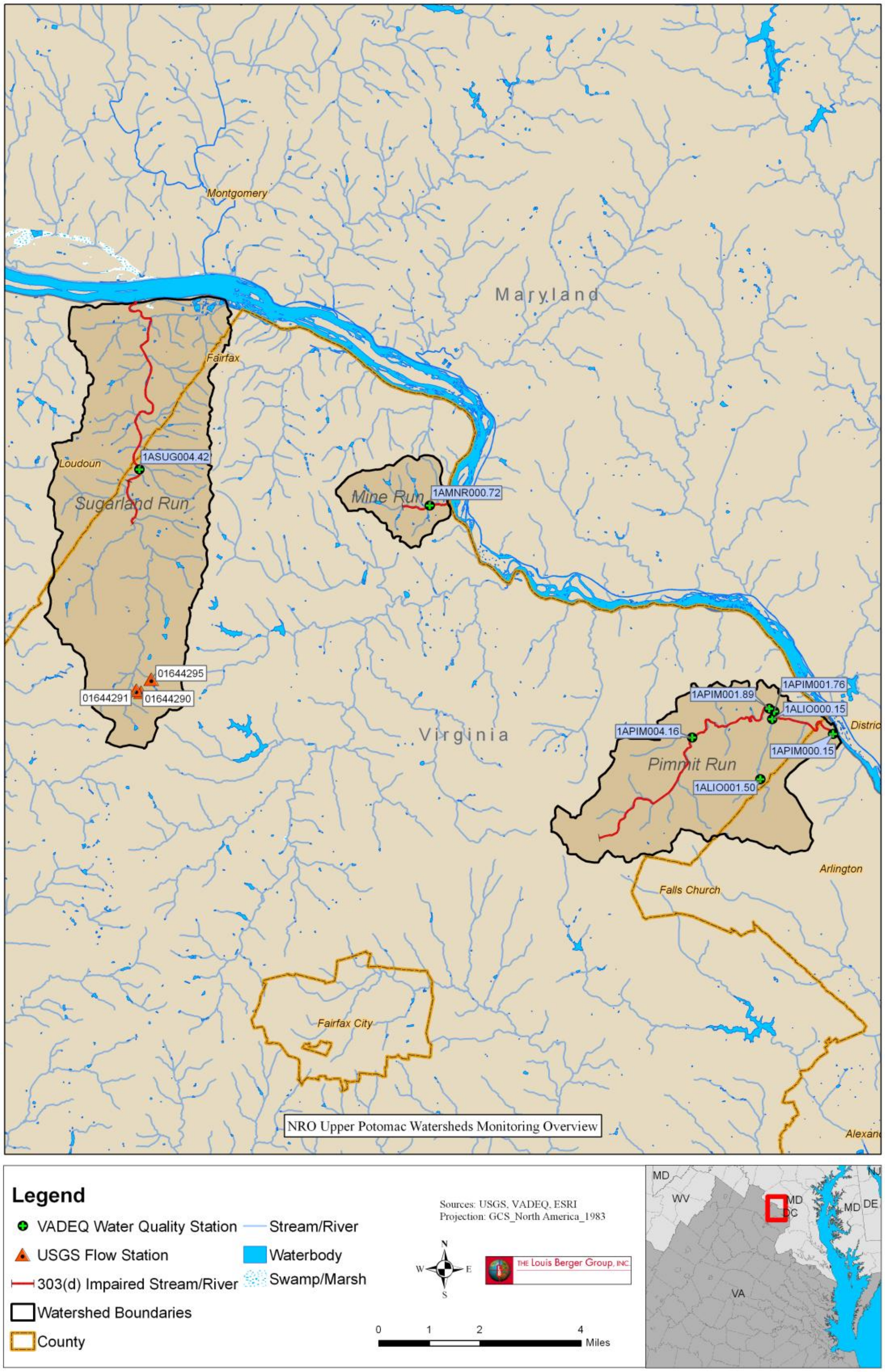


Figure 2-3: VADEQ Water Quality Monitoring Stations and USGS flow Stations in the Sugarland Run, Mine Run, and Pimmit Run Watersheds

2.5 Bacteria Source Assessment

This section focuses on characterizing the sources that potentially contribute to the bacteria loadings in the TMDL watersheds. These sources include permitted facilities, septic systems, livestock, wildlife, and pets. Bacteria source data has been obtained from published sources as well as citizen feedback.

2.5.1 Permitted Facilities

Within the Sugarland Run, Mine Run, and Pimmit Run watersheds there is only one facility that is expected to discharge the contaminant of concern (bacteria), and is addressed under the Virginia Pollutant Discharge Elimination System (VPDES) Program. The facility is located in the Sugarland Run watershed and has a general permit for Domestic Sewage Discharges of Less Than or Equal to 1,000 Gallons per Day (also known as "Single Family Home General Permits"). Facilities holding this type of general permit are expected to discharge the contaminant of concern (bacteria). The permit number, design flow, and permit concentration (cfu/100 ml) for the facility are presented in **Table 2-9**. The available flow data and water quality for the permitted facility was retrieved and analyzed. Average flow for the permitted facility was used in the HSPF model set-up and calibration.

Table 2-9: VPDES Permitted Facilities in the Sugarland Run Watershed (expected to discharge the contaminant of concern)

Permit Number	Facility Type	Watershed	Permit Type	Maximum Design Flow (MGD)	Permit Concentration (cfu/100 ml)
VAG406279	Residence	Sugarland Run	VPDES - General Domestic	0.001	126

There may be other industrial process water and/or stormwater dischargers in the watershed that are authorized to discharge under the VPDES program. These facilities are not expected to discharge the pollutant of concern (bacteria). However, there may be incidental, insignificant levels of bacteria found in these discharges; the discharges are not considered to have a reasonable potential to cause or contribute to exceedances of the Virginia Water Quality Standards and the observed stream impairments. Any inadvertent bacteria discharge would be insignificant, and are not considered in this TMDL

In addition to permits issued under the VPDES program, there are currently seven Municipal Separate Storm Sewer System (MS4) permits issued to cities, counties and other facilities within the TMDL watersheds. These permits are detailed in **Table 2-10**. For Phase I MS4 Permits (for example, Fairfax County), all land-based loadings from developed land use categories (high, medium, and low intensity developed land uses) within the impaired watersheds were allocated to the MS4 permits. For Phase II Permits (i.e. VDOT, Town of Herndon, etc.) all land-based loadings from developed land use categories (high, medium, and low intensity developed land uses) within the most recent United States Census-defined urban areas of the permit boundaries were allocated to the MS4s. The most recent United States decennial census with defined urban areas is the 2010 Census. This approach for developing MS4 allocations is a land-use based approach.

One disadvantage to the land-use based approach is that it is not able to distinguish between urban areas that drain to regulated MS4s and those that drain to other unregulated pervious areas or directly to surface waters. At the time of TMDL development, detailed information regarding the portion of each watershed that drains to a MS4 system was not available, so a conservative, land-use based approach was used. It is important to note that the actual areas within the TMDL watersheds that are subject to a MS4 WLA are those areas that are specifically regulated under the MS4 permit. This TMDL study does not attempt or intend to define the MS4 regulatory area. Rather, the areas used to develop loadings associated with the MS4 permits in this TMDL (developed and Census defined urban areas) are only surrogates for establishing WLAs, estimating a reasonable pollutant loading that is expected to be contributed by these permitted sources. The WLAs for MS4 permittees can be revised in the future, as necessary, if additional information regarding the MS4 drainage areas becomes available or if adaptive management indicates that related loading(s) or reduction strategies would be impacted to a significant degree.

Due to the spatial overlap between MS4 entities and the resulting uncertainty of the appropriate operator of the system, the MS4 loads are aggregated by jurisdiction (Town of Herndon and Fairfax, Loudoun, and Arlington Counties) in the TMDL. In most cases, the boundaries of MS4 areas are not available in enough geospatial detail to disaggregate the MS4 loads and assign individual Waste Load Allocations. EPA, DEQ, and DCR support the aggregation of MS4 WLAs for this reason. Additionally, aggregation encourages stakeholder cooperation for the implementation of appropriate BMPs to address reductions required by the TMDL. **Figure 2-4** depicts the land use and boundaries which were used to develop the MS4 allocations

Table 2-10: MS4 permits within the Sugarland Run, Mine Run, and Pimmit Run Watersheds

Permit Number	MS4 Permit Holder
VA0088587*	Fairfax County
VAR040104	Fairfax County Public Schools
VAR040067	Loudoun County
VAR040060	Town of Herndon
VAR040115	Virginia Department of Transportation
VAR040111	George Washington Memorial Parkway
VA0088579*	Arlington County
*Phase I MS4 Permit	

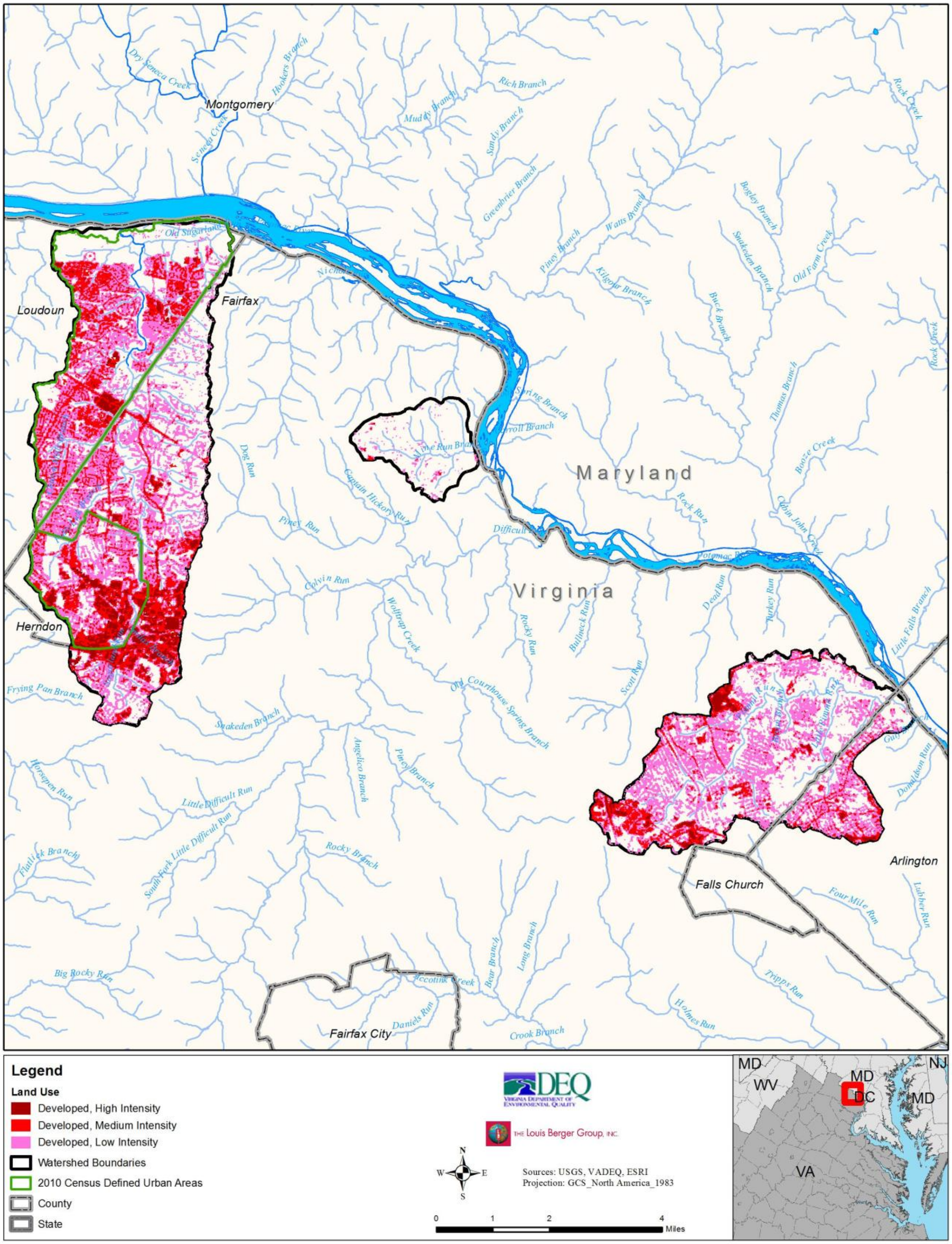


Figure 2-4: MS4 Urban Land Use Distribution (NLCD 2006)

2.5.2 Sanitary Sewer System, Septic Tanks, and Straight Pipes

Houses can be connected to a public sanitary sewer, a septic tank, or the sewage can be disposed of by other means. Estimates of the total number of households in each impaired watershed using each type of waste disposal are presented in this section. Where homes are connected to a centralized wastewater treatment plant, the sewage collection system can be an episodic source of bacteria when there are overflows from pump stations or other sources such as manholes. These are referred to as sanitary sewer overflows (SSOs). SSOs are reported to DEQ and the events cataloged. All reported SSOs were accounted for in this source inventory.

The 2009 U.S. Census Bureau data documents population growth rates and the number of houses per county. The data for Loudoun, Fairfax and Arlington counties were analyzed to establish total population estimates and number of houses within each watershed. The last year the Census Bureau tracked the distribution of houses on sewage systems, septic systems, and other means was 1990. Assuming a similar distribution in 2009, the 1990 distributions were multiplied by the 2009 population and housing unit numbers to estimate the number of houses currently on public sewers, septic tanks and other means. It was assumed that only developed areas contain houses. Thus, estimated numbers for septic, sewer, and other means were prorated to the watershed area based on the ratio of developed acres within the watershed to acres of developed areas within the county. Additionally, data were provided by Arlington and Loudoun Counties concerning numbers of houses with septic tanks in those counties. In cases where the county provided data on septic systems, this data took precedence over Census derived estimates. A summary of the population estimates used for the TMDL watersheds are presented in **Table 2-11**.

In order to determine the amount of bacteria contributed by human sources, it is necessary to estimate the failure rates of septic systems. The percentage of failing septic systems in each TMDL watershed was calculated by multiplying the number of households in each watershed by an estimated 3% septic failure rate (VADEQ, 2011). An estimation of less than 2% was provided by Loudoun County.

The 1990 U.S Census Report category "other means" includes the houses that dispose of sewage in other ways than by public sanitary sewer or a private septic system. Typically, the houses included in this category are assumed to be disposing of sewage directly via straight pipes, if located within 200 feet of a stream. In the case of the Sugarland Run, Mine Run, and Pimmit Run impaired watersheds, stakeholders indicated that there are currently no known straight pipes within 200 ft of the stream. This was based on information from the various county health departments, who commented that immediate action is taken whenever a straight pipe is found. However, since there are potentially some unknown straight pipes within the watershed, a 3% failure rate of homes on "other means" was used for Fairfax and Arlington Counties, and a 2% failure rate was used for any homes on "other means" in Loudoun County.

Table 2-11 shows the estimated number of houses with a failing sewage disposal system (assumed to include both failing septic systems and straight pipes) per county. **Table 2-12** shows the estimated population, number of houses, number of houses on public sewer, number of houses on septic systems and number of failing sewage disposal systems by TMDL watershed.

Table 2-11: Population Estimates for Loudoun, Fairfax, and Arlington Counties

County	Population [1]	Number of Houses[1]	Number of Houses on Public Sewer[2]	Number of Houses on Septic Systems[2]	Number of Houses on "Other Means"[2]	Estimated Number of Houses with a Failing Sewage Disposal System (Failing Septic Systems and Straight Pipes)
Loudoun	301,171	106,032	78,098	26,804	1130	559[†]
Fairfax	1,037,605	393,770	367,684	25,250	836	783[3]
Arlington	217,483	103,803	103,353	312	138	14[3]

[1] Census 2009 estimates

[2] Based upon a ratio of the 2009 Census estimate to the 1990 Census estimate

[3] Based on a septic failure rate of 3% (VADEQ 2011)

[†]Based on Loudoun County's estimated septic failure rate of 2%

Table 2-12: Population Estimates for the Sugarland Run, Mine Run, and Pimmit Run Watersheds

Watershed	Population [1]	Number of Houses[1]	Number of Houses Public Sewer[2]	Number of Houses on Septic Systems[2]	Number of House on "Other Means"[2]	Estimated Number of Houses with a Failing Sewage Disposal System (Failing Septic Systems and Straight Pipes)
Sugarland Run	91,566	33,864	32,309	1,507	48	46[†]
Mine Run	987	375	350	24	1	1[3]
Pimmit Run	50,725	20,737	19,827	872[‡]	38	27[3]

[1] Census 2009 estimates

[2] Based upon 2009 Census estimate and ratio of parameter: 1990 Census estimate

[3] Based on a septic failure rate of 3% (VADEQ 2011)

[†]For portion of Sugarland Run in Loudoun County, a 2% septic failure rate was provided

[‡]This number incorporates Arlington County's estimate of 8 septic systems for the portion of Pimmit Run within Arlington County

2.5.3 Livestock

An inventory of the livestock in the Sugarland Run, Mine Run, and Pimmit Run watersheds was conducted using data and information provided by the United States Department of Agriculture (USDA) Census of Agriculture (2007), the Weldon-Cooper Equine Industry Newsletter Report, and stakeholders input. Livestock information was available for all counties in the watershed. These sources were used to determine the livestock inventories per county, shown in **Table 2-13**, and per TMDL watershed, shown in Table **2-14**. The Loudoun County Soil and Water Conservation District also provided information on livestock estimates for the portion of Sugarland Run within Loudoun County.

Preliminary livestock estimates for each of the impaired watersheds were obtained by:

- Collecting information regarding the total number of livestock, as well as the total number of pastureland acres, in each of the counties included in the study area. This information was obtained from the United States Department of Agriculture (USDA) 2007 Agricultural Census: http://www.agcensus.usda.gov/Publications/2007/Full_Report/index.asp

- Determining the total amount of pastureland in each impaired watershed (calculated via GIS, with 2006 NLCD land cover).

- Incorporating this information into a ratio to determine the estimated number of each type of livestock in the impaired watersheds.

Example Using Hypothetical Numbers:

$$\frac{\text{Acres of Pastureland in Impaired Watershed}^{*}}{\text{Acres of Pastureland in County}^{\#}} = \frac{\text{Number of Horses in Impaired Watershed}}{\text{Number of Horses in County}^{\#}}$$

$$\frac{20\ \text{acres}}{100\ \text{acres}} = \frac{\text{X}}{50\ \text{horses}}$$

$$\text{X} = 10\ \text{horses}$$

Obtained from NLCD Land Use GIS Layer
 # Obtained from the 2007 Agricultural Census

Table 2-13: Livestock Estimates for Arlington, Fairfax and Loudoun Counties[1]

County	Beef Cows	Milk Cows	Other Cattle[3]	Hogs/ Pigs	Sheep and Lambs	Chickens	Chickens (Layers)	Turkeys	Horses[2]
Loudoun	11,595	214	8,887	137	2,410	255	3,892	120	10,000
Fairfax	50	0	0	83	48	0	279	0	5,000
Arlington	0	0	0	0	0	0	0	0	0

[1] Based on USDA 2007 Agricultural Census Data (http://www.agcensus.usda.gov/Publications/2007/Full_Report/index.asp)
[2] Based on numbers provided in letter from University of Virginia's Weldon Cooper Center for Public Service, 2011
[3] Cattle not shipped directly for slaughter

Table 2-14: Livestock Estimates for the Sugarland Run[1], Mine Run, and Pimmit Run Watersheds*

TMDL Watershed	Beef Cows	Milk Cows	Other Cattle[3]	Hogs/ Pigs	Sheep and Lambs	Chickens	Chickens (Layers)	Turkeys	Horses[2]
Sugarland Run[1]	11	0	9	0	2	0	4	0	15
Mine Run	0	0	0	0	0	0	1	0	23
Pimmit Run	0	0	0	0	0	0	1	0	25

* Based on USDA 2007 Agricultural Census Data (http://www.agcensus.usda.gov/Publications/2007/Full_Report/index.asp)
[1] Based on input from Loudoun County and USDA 2007 Agriculture Data
[2] Based on numbers provided in letter from University of Virginia's Weldon Cooper Center for Public Service, 2011
[3] Cattle not shipped directly for slaughter

The livestock inventory was used to determine the fecal coliform loading by livestock in the watershed. **Table 2-15** shows the average fecal coliform production by animal per day contributed for each type of livestock.

Table 2-15: Livestock Present in TMDL Watersheds

Livestock Type	Daily Fecal Coliform Production (cfu/day)	Reference
Other Dairy Cow (including heifers)	1.16E+10	Virginia Tech, 2000
Beef Cows	3.3E+10	Virginia Tech, 2000
Dairy Cows	2.52E+10	Virginia Tech, 2000
Hogs	1.08E+10	ASAE, 1998
Sheep	2.70E+10	Virginia Tech, 2000
Horses	4.20E+08	Virginia Tech, 2000
Chickens	1.36E+08	ASAE. 1998

The impact of fecal coliform loading from livestock is dependent upon whether loadings are directly deposited into the stream, or indirectly delivered to the stream via surface runoff. For this TMDL, fecal coliform deposited while livestock were in confinement or grazing was considered indirect deposit, and fecal coliform deposited when livestock directly defecate into the stream was considered direct deposit. The distribution of daily fecal coliform loading between direct and indirect deposits was based on livestock daily schedules.

For the Sugarland, Mine Run and Pimmit Run watersheds, the initial estimates of the beef cattle daily schedule were based on the Difficult Run TMDL.

The daily schedule for beef cattle is presented in **Table 2-16** and the daily schedule for dairy cows is presented in **Table 2-17**. The time beef cattle and dairy cows spend in the pasture or loafing was used to determine the fecal coliform load deposited indirectly. The directly deposited fecal coliform load from livestock was based on the amount of time they spend in the stream.

Table 2-16: Daily Schedule for Beef Cattle		
Month	Time Spent in:	
	Pasture (Hour)	Stream (Hour)
January	24	0.50
February	24	0.50
March	24	0.75
April	24	1.00
May	24	1.00
June	24	1.25
July	24	1.25
August	24	1.25
September	24	1.00
October	24	0.75
November	24	0.75
December	24	0.50

Table 2-17: Daily Schedule for Dairy Cows		
Month	Time Spent in:	
	Pasture (Hour)	Stream (Hour)
January	7.70	0.25
February	7.70	0.25
March	8.60	0.50
April	10.10	0.75
May	10.80	0.75
June	11.30	1.00
July	11.80	1.00
August	11.80	1.00
September	11.80	0.75
October	11.50	0.50
November	10.80	0.50
December	9.40	0.25

2.5.4 Land Application of Manure

Land application of the manure that cattle produce while in confinement is a typical agricultural practice. For these TMDLs, beef cattle are only present in the Sugarland Run watershed. The manure produced by confined livestock was directly applied on the pasturelands, and was treated as an indirect source in the development of the Sugarland Run TMDL.

2.5.5 Wildlife

The wildlife inventory for the TMDL watersheds was developed based on numbers used in the Difficult Run Bacteria TMDL Report (VADEQ) and provided by the Department of Game and Inland Fisheries (DGIF). The number of wildlife in the watershed was estimated by combining typical wildlife densities with available stream wildlife habitat. Typical wildlife densities provided by DGIF and stakeholder input are presented in **Table 2-18**. This information was used to determine the wildlife population estimates for each TMDL watershed as shown in **Table 2-19.**

Table 2-18: Wildlife Densities in the TMDL Watersheds[1]

Wildlife Type	Land Use Requirements	Animal Density (Number of Animals/Acre)
Deer	Entire watershed	0.12 animals/acre
Raccoon	Entire watershed	0.31 animals/acre
Muskrat	Within 60 feet of streams and ponds (urban, grassland, forest, wetlands)	0.23 animals/acre
Beaver	Per mile of rivers and streams	2 animals/mile
Goose-Summer	Within 300 feet of streams and ponds (urban, grassland, wetlands)	3.5 animals/acre
Goose-winter	Within 300 feet of streams and ponds (urban, grassland, wetlands)	3.75 animals/acre
Duck- Summer	Within 300 feet of streams and ponds (urban, grassland wetlands, forest)	0.23 animals/acre
Duck- Winter	Within 300 feet of streams and ponds (urban, grassland wetlands, forest)	0.37 animals/acre
Turkey	Entire watershed excluding urban land uses	0.01 animals/acre

[1] Source: Difficult Run Bacteria TMDL Report (VADEQ), Department of Game and Inland Fisheries (DGIF), stakeholder input

Table 2-19: Wildlife Estimates for the Sugarland Run, Mine Run, and Pimmit Run Watersheds[1]

TMDL Watershed	Acres	Deer	Raccoon	Muskrat	Beaver	Goose-Summer	Goose Winter	Duck Summer	Duck Winter	Wild Turkey
Sugarland Run	14,529	1,744	4,504	178	118	9,531	10,153	901	1,447	37
Mine Run	1,593	191	494	21	15	506	538	111	177	10
Pimmit Run	7,843	941	2,431	55	37	1877	1,998	268	434	26

[1] Based on densities used in the Difficult Run Bacteria TMDL Report (VADEQ) and provided by the Department of Game and Inland Fisheries (DGIF), stakeholder input

The fecal coliform production and percentage of the day in stream access for each wildlife animal is presented in **Table 2-20**.

Table 2-20: Daily Schedule and Fecal Coliform Production for Wildlife		
Wildlife Type	**Daily Fecal Coliform Production (cfu/day)**	**Percentage of Day Spent in Stream**
Ducks	2.43E+09	75%
Goose	7.99E+08	50%
Deer	3.47E+08	1%
Beaver	2.00E+05	90%
Raccoons	1.13E+08	10%
Wild Turkey	9.30E+07	5%
Muskrat	2.50E+07	50%
Mallard	2.43E+09	50%

2.5.6 Pets

The two types of domestic pets that were considered to be potential bacteria sources in this watershed were cats and dogs. As of 2007, the American Veterinary Medical Association estimates densities of 0.632 dogs per household and 0.713 cats per household. **Table 2-21** shows the number of pets per TMDL watershed based on AVMA densities. Fecal coliform loading from pets was estimated based on daily fecal coliform production rate of 5.04 $x10^2$ cfu/day per cat and 4.09 $x10^9$ cfu/day per dog (LIRPB, 1978).

Table 2-21: Pet Inventory for the Sugarland Run, Mine Run and Pimmit Run Watersheds[1]			
Watershed	**Households**	**Estimated Dog Population**	**Estimated Cat Population**
Sugarland Run	33,864	21,402	24,145
Mine Run	375	240	270
Pimmit Run	20,737	13,100	14,790
[1]Based on American Veterinary Medical Association Pet Densities			

3.0 Modeling Approach

This section describes the modeling approach used in the TMDL development for Sugarland Run, Mine Run, and Pimmit Run. Information provided in this chapter includes a summary of sources represented in the model, assumptions used, model set-up, model calibration and validation, and an analysis of the existing bacteria load in each of the impaired watersheds.

3.1 Modeling Goals

The goals of the modeling approach were to develop a predictive tool for each of the impaired waterbodies that can:

- Represent the watershed characteristics.
- Represent the point and non-point sources of fecal coliform and their respective contributions.
- Use input time series data (rainfall and flow) and kinetic data (die-off rates of fecal coliform).
- Estimate the instream pollutant concentrations and loadings under various hydrologic conditions.
- Allow for direct comparisons between the instream conditions and the water quality criteria.

3.2 Watershed Boundaries

The Sugarland Run, Mine Run, and Pimmit Run watersheds are within a hydrologic drainage area that is approximately 72,140 acres or 113 square miles. This area is larger than the individual bacteria impaired watersheds because of the incorporation of the Difficult Run watershed, which was necessary for the hydrology calibration. The hydrologic modeling area drains portions of Loudoun, Arlington and Fairfax counties. **Figure 3-1** shows both the bacteria impaired watersheds and the hydrologic modeling area.

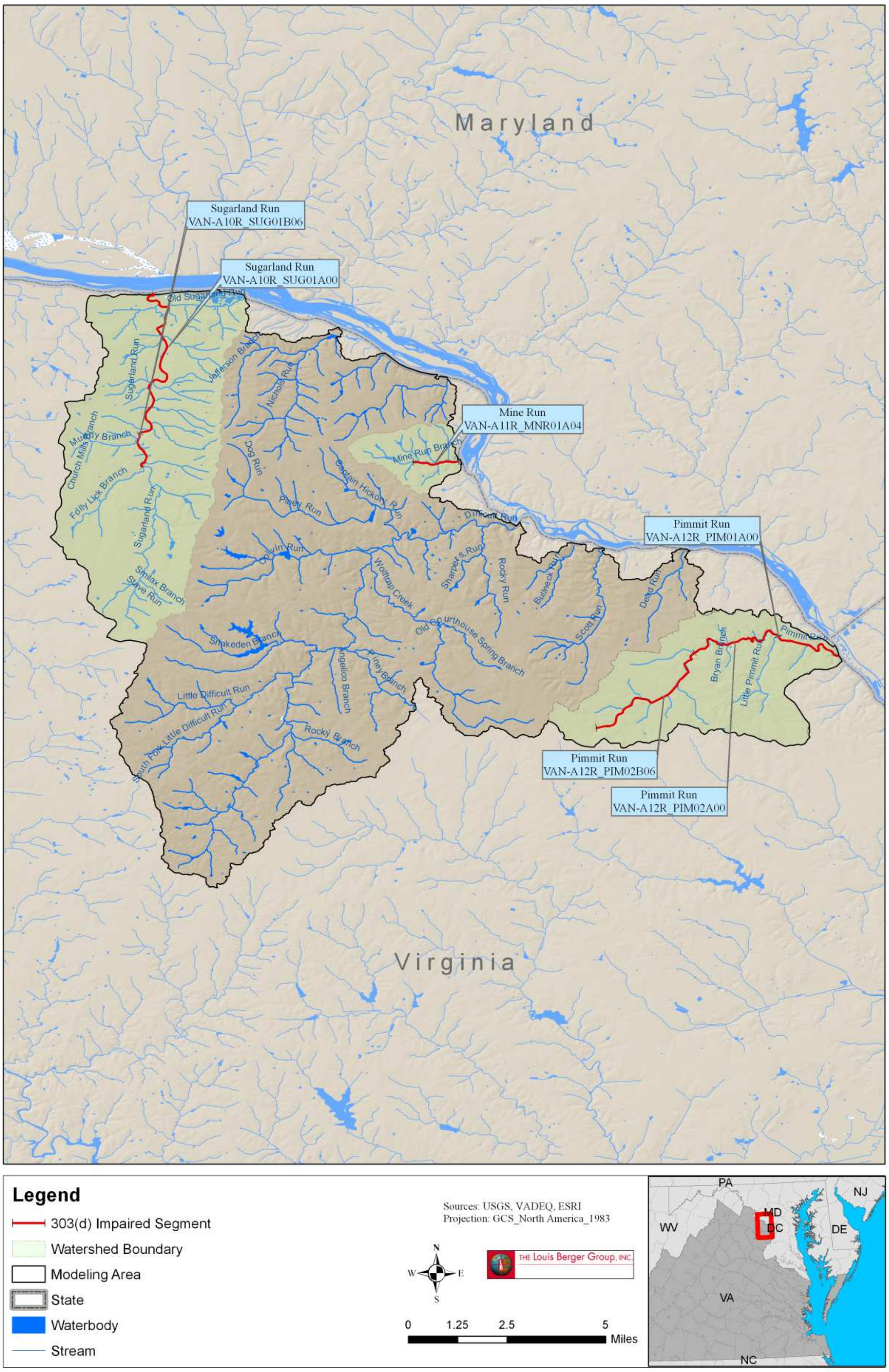


Figure 3-1: Watershed Boundaries and Hydrologic Modeling Area

3.3 Modeling Strategy

The Hydrologic Simulation Program-Fortran (HSPF) model was selected and used to predict the instream water quality conditions under varying scenarios of rainfall and fecal coliform loading. The results from the developed model are subsequently used to develop the TMDL allocations based on the existing fecal coliform load.

HSPF is a hydrologic, watershed-based water quality model. Consequently, HSPF can explicitly account for specific watershed conditions, seasonal variations in rainfall and climate conditions, and activities and uses related to fecal coliform loading.

The modeling process in HSPF starts with the following steps:

- delineate the watershed into smaller subwatersheds
- enter the physical data that describe each subwatershed and stream segment
- enter values for the rates and constants that describe the sources and the activities related to the fecal coliform loading in the watershed

These steps are discussed in further detail in the next sections.

3.4 Watershed Delineation

For this TMDL, the hydrologic modeling are was delineated into 45 smaller subwatersheds to represent the watershed characteristics and to improve the accuracy of the HSPF model. This delineation was created using a Digital Elevation Model (DEM), stream reaches obtained from the National Hydrography Dataset (NHD), and stream flow and instream water quality data. Size distributions of the 45 subwatersheds are presented in **Table 3-1. Figure 3-2** shows the delineated subwatersheds for the hydrologic modeling area as well as the locations of the USGS flow station and the Reagan National Airport weather station used in modeling. The full hydrologic modeling area, including all 45 subwatersheds, was used in the hydrologic modeling. However, only the 11 subwatersheds corresponding to the Sugarland Run, Mine Run, and Pimmit Run bacteria impaired watersheds (presented in chapters 1 and 2) were used for the water quality modeling.

Table 3-1: Sugarland Run, Mine Run, and Pimmit Run Hydrologic Modeling Area Segments

Modeling Segment	Drainage Area (acres)
1	2,807
2	2,120
3	2,619
4	1,738
5	4,234
6	414
7	1,186
8	2,447
9	1,006
10	1,774
11	1,602
12	277
13	1,452
14	741
15	3,575
16	508
17	1,735
18	1,004
19	1,232
20	62
21	1,752
22	687
23	2,943
24	276
25	663
26	1,963
27	1,725
28	951
29	4,188
30	23
31	1,076
32	1,024
33	1,744
34	1,325
35	2,473
36	800
37	2,095
38	1,163
39	3,275
40	1,759
41	698
42	1,481
43	3,773
44	322
45	1,428
Total	**72,140**

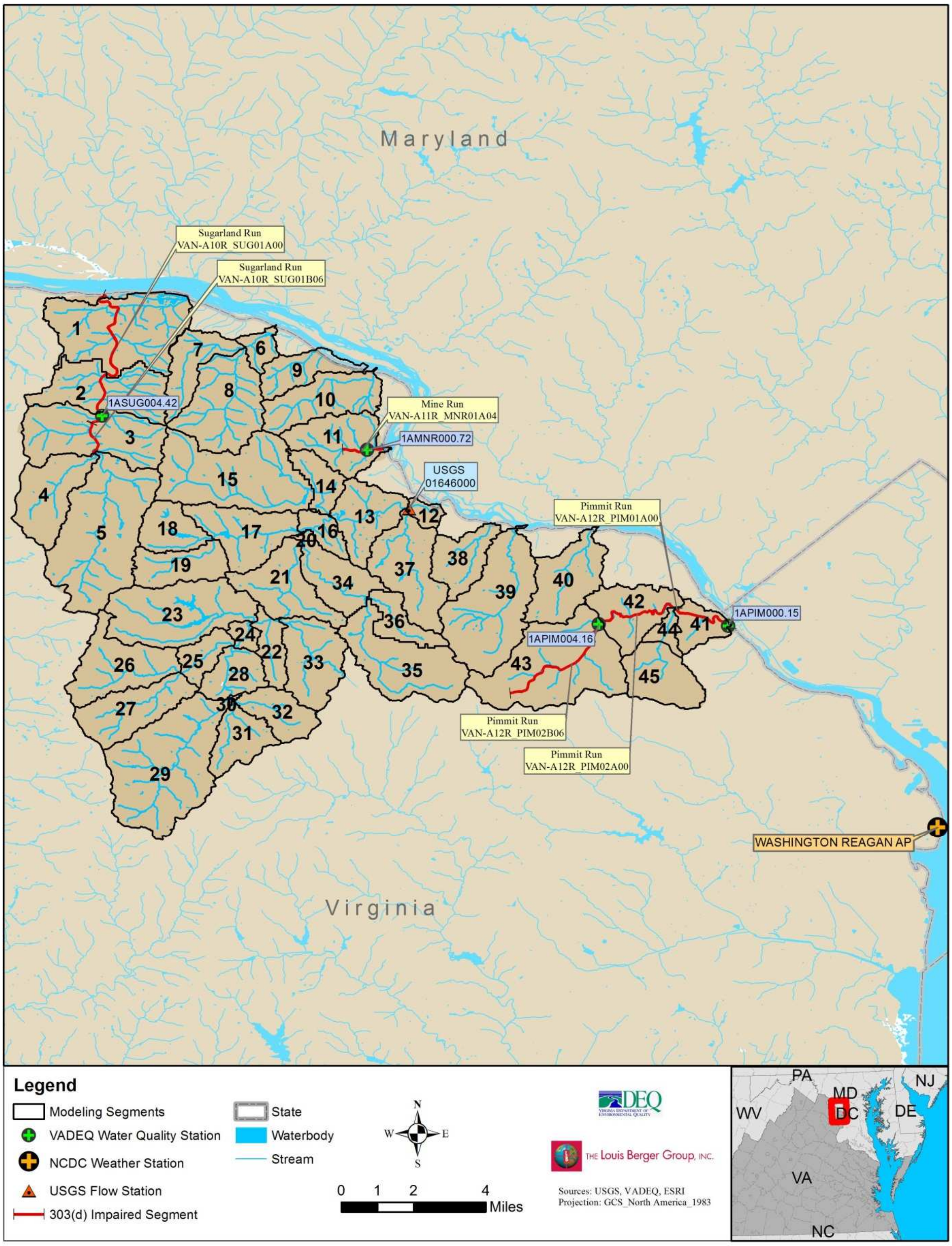


Figure 3-2: Sugarland Run, Mine Run, and Pimmit Run Hydrologic Modeling Area Segments

3.5 Land Use

The distribution of land uses in the hydrologic modeling area, by land area and respective percentage, are presented in **Table 3-2**. The dominant land uses in the hydrologic modeling are Deciduous Forest (35%) and Developed Low Intensity (22%).

Table 3-2: NLCD 2006 Land Use Distribution in the Sugarland Run, Mine Run, and Pimmit Run Hydrologic Modeling Area

Stream Segment	Bare Land	Cultivated Crops	Deciduous Forest	Developed, High Intensity	Developed, Low Intensity	Developed, Medium Intensity	Developed, Open Space	Evergreen Forest	Grassland/ Herbaceous	Mixed Forest	Open Water	Palustrine Emergent Wetland	Palustrine Forested Wetland	Palustrine Scrub/ Shrub Wetland	Pasture/ Hay	Scrub/ Shrub	Unconsolidated Shore	Total
1	1.7	19.7	391.2	45.8	813.2	595.9	446.5	5.1	28.3	24.9	15.6	5.1	333.0	19.3	20.5	41.4	0.2	**2,807.3**
2	0.2	7.8	463.7	48.0	665.6	256.6	303.1	93.1	25.8	66.9	2.9	0.2	59.7	1.6	33.0	91.7	0.0	**2,119.8**
3	0.0	4.7	398.1	56.1	1,102.9	497.4	378.5	44.6	17.1	45.4	0.2	0.2	17.7	0.2	6.1	49.9	0.0	**2,619.1**
4	0.0	0.0	175.0	62.9	767.5	366.2	303.4	3.1	6.1	17.5	0.4	0.0	20.0	1.6	4.4	9.6	0.0	**1,737.8**
5	4.7	0.0	571.5	616.6	1,412.0	1,084.1	373.0	16.0	3.3	37.8	11.6	2.0	67.7	7.3	0.0	25.9	0.2	**4,233.9**
6	0.0	6.0	284.7	0.0	4.4	0.5	52.2	0.5	12.0	3.6	4.6	0.7	16.7	11.5	8.8	7.4	0.0	**413.6**
7	0.0	29.5	680.7	0.0	39.4	0.2	132.2	46.0	15.6	42.9	0.4	0.7	12.5	0.0	101.1	85.3	0.0	**1,186.4**
8	0.0	9.9	1,499.4	0.9	106.7	3.0	599.9	18.0	19.4	60.0	3.8	1.1	12.7	0.2	0.1	111.7	0.2	**2,446.9**
9	0.0	2.7	547.9	0.0	39.1	1.3	176.8	15.1	8.2	31.5	56.9	7.2	49.9	1.3	11.8	56.8	0.0	**1,006.5**
10	0.2	26.3	1,077.8	2.2	51.8	2.9	344.0	26.5	16.6	48.4	4.7	1.3	31.7	4.2	15.3	119.8	0.0	**1,773.9**
11	0.6	17.8	786.6	1.8	80.2	8.3	473.2	32.1	10.0	50.1	10.7	2.2	24.8	4.0	15.1	84.6	0.0	**1,602.2**
12	0.7	0.0	230.1	0.2	7.3	1.2	9.0	1.7	0.4	6.3	6.8	0.4	9.1	0.0	1.1	2.7	0.4	**277.5**
13	0.0	77.7	888.7	0.0	75.9	2.7	126.7	47.1	4.6	65.3	4.7	0.7	79.6	4.8	22.2	50.7	0.2	**1,451.7**
14	0.0	3.8	374.0	6.9	56.5	19.2	196.3	12.2	2.9	25.2	0.0	0.2	15.2	0.2	0.4	28.0	0.0	**741.1**
15	0.0	28.9	1,106.2	14.4	658.2	174.5	1,078.4	102.5	15.7	94.9	11.8	4.4	96.1	22.2	1.4	164.8	0.0	**3,574.5**
16	0.0	6.3	167.9	0.0	103.2	7.0	76.0	34.1	2.1	20.9	0.0	0.0	69.1	7.4	0.2	13.6	0.0	**508.0**
17	0.2	51.0	591.6	4.3	327.7	54.6	352.5	57.2	10.4	53.4	14.7	2.4	70.1	7.3	80.6	57.0	0.0	**1,735.1**
18	0.0	6.2	252.7	7.4	333.0	117.7	181.2	1.3	2.1	10.2	31.4	1.3	25.5	0.2	18.7	14.9	0.0	**1,003.8**
19	0.4	21.3	309.2	132.9	225.0	290.7	175.0	12.1	2.0	15.3	0.2	0.2	26.5	0.0	11.5	9.1	0.0	**1,231.7**
20	0.0	1.2	13.3	0.0	13.2	0.6	6.4	1.0	0.1	1.3	0.0	0.0	13.6	9.4		1.8	0.0	**62.0**
21	0.0	79.3	578.4	16.2	298.6	97.7	254.2	53.7	10.2	61.0	1.8	0.7	115.5	43.9	67.1	73.6	0.0	**1,751.9**
22	0.0	11.0	357.2	0.0	50.9	2.9	93.3	34.9	2.9	50.5	0.0	1.3	38.8	8.7	8.8	25.9	0.0	**687.2**
23	0.2	11.7	1,238.5	67.0	614.7	362.1	312.1	23.2	1.8	73.4	68.0	2.7	129.5	3.3	11.5	23.8	0.0	**2,943.4**
24	0.0	1.3	166.7	0.0	22.6	0.9	22.8	7.3	0.7	7.8	0.0	0.0	34.9	0.0	0.9	10.0	0.0	**275.8**
25	0.8	1.5	396.6	0.5	28.5	0.2	65.6	24.6	3.3	42.0	0.7	0.2	61.2	8.0	10.2	18.8	0.0	**662.7**
26	1.6	34.8	1,178.3	2.1	151.4	13.4	246.1	37.7	6.2	133.4	1.3	1.1	90.4	4.0	23.4	37.5	0.0	**1,962.8**

Table 3-2: NLCD 2006 Land Use Distribution in the Sugarland Run, Mine Run, and Pimmit Run Hydrologic Modeling Area

Stream Segment	Bare Land	Cultivated Crops	Deciduous Forest	Developed, High Intensity	Developed, Low Intensity	Developed, Medium Intensity	Developed, Open Space	Evergreen Forest	Grassland/ Herbaceous	Mixed Forest	Open Water	Palustrine Emergent Wetland	Palustrine Forested Wetland	Palustrine Scrub/ Shrub Wetland	Pasture/ Hay	Scrub/ Shrub	Unconsolidated Shore	Total
27	11.2	17.6	911.6	0.2	233.7	7.8	236.7	64.9	4.7	78.9	2.2	0.2	82.0	0.9	14.0	57.9	0.2	**1,724.7**
28	0.0	11.7	510.3	0.0	52.0	0.2	150.4	37.7	3.4	65.0	0.4	0.9	72.5	5.0	9.3	32.1	0.0	**950.9**
29	13.0	62.9	1,510.8	323.9	525.3	524.3	559.1	153.3	26.4	141.9	12.7	2.0	182.2	6.8	39.1	104.4	0.4	**4,188.5**
30	0.0	0.0	10.2	0.0	1.7	0.0	1.2	0.0	0.0	0.7	0.0	0.2	8.5	0.0	0.0	0.7	0.0	**23.2**
31	0.2	6.7	459.8	19.2	155.6	53.2	240.8	19.4	5.4	41.9	0.2	0.2	15.3	1.1	21.3	36.1	0.0	**1,076.5**
32	0.0	2.7	334.1	1.0	281.7	30.1	221.3	29.6	2.0	46.8	0.9	0.2	36.1	2.9	5.3	29.4	0.0	**1,024.2**
33	0.0	23.7	654.5	2.9	460.3	28.7	334.5	43.5	1.3	72.3	0.0	0.3	66.7	12.8	3.8	38.6	0.0	**1,743.9**
34	0.0	26.4	447.4	6.0	273.0	64.1	252.1	49.9	3.3	55.7	0.9	0.7	56.4	22.0	30.2	37.1	0.0	**1,325.1**
35	1.1	1.8	477.4	201.2	832.9	347.2	430.7	35.7	2.0	52.6	2.7	0.7	57.2	0.7	2.7	26.9	0.0	**2,473.5**
36	0.2	8.9	184.0	147.5	194.0	120.3	72.5	5.5	0.9	16.9	0.0	0.2	34.9	0.7	3.8	9.9	0.0	**800.2**
37	0.0	32.2	970.8	101.7	258.4	120.1	234.4	124.7	9.1	88.8	2.7	0.4	26.0	0.0	55.5	68.8	0.8	**2,094.5**
38	4.4	20.6	685.8	3.6	78.5	10.2	167.2	48.5	6.2	51.2	1.9	0.0	22.8	1.1	28.6	32.0	0.4	**1,163.1**
39	1.8	4.5	1,087.2	350.1	729.6	571.0	270.9	62.8	1.8	96.3	8.1	0.9	48.0	1.3	7.8	32.5	0.2	**3,274.8**
40	0.0	0.0	524.2	58.4	560.2	121.0	232.6	86.0	3.8	68.8	5.6	0.0	50.0	0.9	17.3	29.7	0.0	**1,758.6**
41	0.0	0.0	290.9	0.2	229.4	25.7	71.8	7.3	0.0	31.3	0.0	0.0	35.2	0.0	0.0	6.2	0.0	**698.1**
42	0.0	11.1	407.4	6.2	492.1	63.8	273.9	61.2	5.3	66.7	0.0	0.0	44.5	0.4	14.2	34.1	0.0	**1,481.0**
43	0.4	4.4	654.2	148.0	1,629.8	548.7	540.4	53.1	2.0	88.8	0.0	0.0	68.0	6.2	5.3	23.4	0.0	**3,772.8**
44	0.0	0.0	89.6	0.0	93.1	6.6	78.7	6.0	1.3	19.1	0.0	0.0	23.2	0.0	0.0	4.7	0.0	**322.4**
45	0.0	0.0	351.1	28.7	575.9	168.9	160.5	30.0	0.4	54.2	0.0	0.0	47.7	0.0	0.7	9.5	0.0	**1,427.6**
Total	**43.8**	**695.4**	**25,287.4**	**2,485.2**	**15,706.8**	**6,773.9**	**11,308.2**	**1,670.2**	**307.0**	**2,227.8**	**291.4**	**43.4**	**2,498.5**	**233.6**	**733.2**	**1,830.4**	**3.5**	**72,139.8**

3.6 Land Use Reclassification

There are 17 land use classes present in the hydrologic modeling area. These land use types were consolidated into nine land use categories to meet modeling goals, facilitate model parameterization, and reduce modeling complexity (**Table 3-3)**. This reclassification reduced the 17 land use types to a representative number of categories that best describe conditions and the dominant fecal coliform and *E. coli* source categories in the watersheds. Land use reclassification was based on similarities in hydrologic characteristics and potential fecal coliform production characteristics. The reclassified land uses are presented in **Table 3-4** for the hydrologic modeling area.

Table 3-3: NLCD 2006 Land Use Reclassification Scheme

NLCD 2006 Landuse Category	Reclassification
Cultivated Crops	Cropland
Bare Land	
Developed High Intensity	Developed High Intensity
Developed Low Intensity	Developed Low Intensity
Developed, Medium Intensity	Developed, Medium Intensity
Deciduous Forest	Forest
Evergreen Forest	
Mixed Forest	
Scrub/Shrub	
Grassland/Herbaceous	
Developed, Open Space	Other Urban
Pasture/Hay	Pasture
Open Water	Water
Palustrine Emergent Wetland	Wetland
Palustrine Forested Wetland	
Palustrine Scrub/Shrub Wetland	
Unconsolidated Shore	

Table 3-4: NLCD 2006 Land Use Distribution in Sugarland Run, Mine Run and Pimmit Run Hydrologic Modeling Area

Stream Segment	Cropland	Developed High Intensity	Developed Low Intensity	Developed, Medium Intensity	Forest	Other Urban	Pasture	Water	Wetland	Grand Total
1	21.3	45.8	813.2	595.9	490.9	446.5	20.5	15.6	357.6	**2,807.3**
2	8.0	48.0	665.6	256.6	741.2	303.1	33.0	2.9	61.5	**2,119.8**
3	4.7	56.1	1,102.9	497.4	555.0	378.5	6.1	0.2	18.2	**2,619.1**
4		62.9	767.5	366.2	211.3	303.4	4.4	0.4	21.6	**1,737.8**
5	4.7	616.6	1,412.0	1,084.1	654.5	373.0		11.6	77.3	**4,233.9**
6	6.0		4.4	0.5	308.2	52.2	8.8	4.6	28.9	**413.6**
7	29.5		39.4	0.2	870.5	132.2	101.1	0.4	13.2	**1,186.4**
8	9.9	0.9	106.7	3.0	1,708.5	599.9	0.1	3.8	14.2	**2,446.9**
9	2.7		39.1	1.3	659.5	176.8	11.8	56.9	58.4	**1,006.5**
10	26.6	2.2	51.8	2.9	1,289.2	344.0	15.3	4.7	37.3	**1,773.9**
11	18.4	1.8	80.2	8.3	963.4	473.2	15.1	10.7	31.0	**1,602.2**
12	0.7	0.2	7.3	1.2	241.3	9.0	1.1	6.8	10.0	**277.5**
13	77.7		75.9	2.7	1,056.5	126.7	22.2	4.7	85.3	**1,451.7**
14	3.8	6.9	56.5	19.2	442.2	196.3	0.4		15.6	**741.1**
15	28.9	14.4	658.2	174.5	1,484.1	1,078.4	1.4	11.8	122.8	**3,574.5**
16	6.3		103.2	7.0	238.7	76.0	0.2		76.5	**508.0**
17	51.3	4.3	327.7	54.6	769.6	352.5	80.6	14.7	79.8	**1,735.1**
18	6.2	7.4	333.0	117.7	281.2	181.2	18.7	31.4	27.1	**1,003.8**
19	21.8	132.9	225.0	290.7	347.7	175.0	11.5	0.2	26.7	**1,231.7**
20	1.2		13.2	0.6	17.6	6.4			23.0	**62.0**
21	79.3	16.2	298.6	97.7	777.0	254.2	67.1	1.8	160.1	**1,751.9**
22	11.0		50.9	2.9	471.4	93.3	8.8		48.8	**687.2**
23	11.9	67.0	614.7	362.1	1,360.6	312.1	11.5	68.0	135.5	**2,943.4**
24	1.3		22.6	0.9	192.5	22.8	0.9		34.9	**275.8**
25	2.3	0.5	28.5	0.2	485.3	65.6	10.2	0.7	69.4	**662.7**
26	36.4	2.1	151.4	13.4	1,393.2	246.1	23.4	1.3	95.5	**1,962.8**
27	28.8	0.2	233.7	7.8	1,118.0	236.7	14.0	2.2	83.3	**1,724.7**
28	11.7		52.0	0.2	648.5	150.4	9.3	0.4	78.3	**950.9**
29	75.9	323.9	525.3	524.3	1,936.7	559.1	39.1	12.7	191.5	**4,188.5**
30			1.7		11.6	1.2			8.7	**23.2**
31	6.9	19.2	155.6	53.2	562.6	240.8	21.3	0.2	16.6	**1,076.5**
32	2.7	1.0	281.7	30.1	442.0	221.3	5.3	0.9	39.2	**1,024.2**
33	23.7	2.9	460.3	28.7	810.3	334.5	3.8		79.7	**1,743.9**
34	26.4	6.0	273.0	64.1	593.4	252.1	30.2	0.9	79.0	**1,325.1**
35	2.9	201.2	832.9	347.2	594.7	430.7	2.7	2.7	58.6	**2,473.5**
36	9.1	147.5	194.0	120.3	217.2	72.5	3.8		35.8	**800.2**
37	32.2	101.7	258.4	120.1	1,262.1	234.4	55.5	2.7	27.3	**2,094.5**
38	25.0	3.6	78.5	10.2	823.7	167.2	28.6	1.9	24.4	**1,163.1**
39	6.2	350.1	729.6	571.0	1,280.6	270.9	7.8	8.1	50.4	**3,274.8**
40		58.4	560.2	121.0	712.5	232.6	17.3	5.6	50.9	**1,758.6**
41		0.2	229.4	25.7	335.8	71.8			35.2	**698.0**
42	11.1	6.2	492.1	63.8	574.7	273.9	14.2		44.9	**1,481.0**
43	4.9	148.0	1,629.8	548.7	821.5	540.4	5.3		74.2	**3,772.8**
44			93.1	6.6	120.7	78.7			23.2	**322.4**
45		28.7	575.9	168.9	445.2	160.5	0.7		47.7	**1,427.6**
Total	**739.3**	**2,485.2**	**15,706.8**	**6,773.9**	**31,322.8**	**11,308.2**	**733.2**	**291.4**	**2,779.0**	**72,139.8**

3.7 Hydrographic Data

Hydrographic data describing the stream network were obtained from the National Hydrography Dataset (NHD). This data was used for HSPF model development and TMDL development. Stream channels in the hydrologic modeling area were represented as trapezoidal channels. The channel slopes were estimated using the reach length and the corresponding change in elevation from DEM data. Model representation of the stream reach segment is presented in **Appendix A.**

3.8 Fecal Coliform Sources Representation

This section demonstrates how the fecal coliform sources identified in Chapter 2 were included or represented in the model. These sources include permitted sources, human sources (failed septic systems and straight pipes), livestock, wildlife, pets, and land application of manure.

3.8.1 Permitted Facilities

Based on data obtained from VADEQ, there is one facility that is addressed under the Virginia Pollutant Discharge Elimination System (VPDES) Program. The permit number, design flow and permit concentration (cfu/100 mL) for this facility (VAG406279) was presented in **Table 2-9**.

For TMDL development, average discharge flow values were considered representative of flow conditions at the permitted facility, and were used in HSPF model set-up and calibration. For TMDL allocation development, the permitted facility was represented as a constant source discharging at its maximum permitted design flow and permitted bacteria concentration.

Reported SSOs in any of the impaired watersheds were incorporated into the source inventory for model calibration. However, SSOs did not receive a wasteload allocation as they are unauthorized discharges.

3.8.2 Failed Septic Systems

Failed septic system loading to the watershed can be direct (point) or land-based (indirect or nonpoint), depending on the proximity of the septic system to the stream. As explained in Section 2.5.2, the total number of septic systems in the Sugarland Run, Mine Run and Pimmit Run watersheds was estimated at 2,403 systems.

For TMDL development, it was assumed that a 3% failure rate for septic systems would be representative of conditions in the watersheds (for Loudoun County, which Sugarland falls partially within, a failure rate of 2% was used). This corresponds to a total of 72 failed septic systems in the Sugarland Run, Mine Run, and Pimmit Run watersheds. The number of houses on other means of sewage disposal was estimated by obtaining the ratio of the 1990 "other means" number to the 1990 total households number and multiplying this ratio by the 2009 households estimate. **Table 2-12** indicates that there are approximately 87 homes in the Sugarland Run, Mine Run, and Pimmit Run watersheds that are on "other means" for sewage disposal. As explained in Section 2.5.2, the total number of houses with a failing sewage disposal system (combination of failing septic systems and failing "other means" systems) in the Sugarland Run, Mine Run and Pimmit Run watersheds was estimated at 74.

In each subwatershed, the load from failing sewage disposal systems was calculated as the product of the total number of septic systems, septic systems failure rate, flow rate of septic discharge, typical fecal concentration in septic outflow, and the average household size in the watershed. The septic systems' design flow of 75 gallons per person per day and a fecal coliform concentration of 10,000 cfu/100 mL (Horsley & Whitten, 1996) were used in the fecal coliform load calculations. Failed sewage disposal systems were represented as constant sources of fecal coliform. **Table 3-5** shows the distribution of the failed sewage disposal systems in the watershed.

Table 3-5: Failed Sewage Disposal Systems Assumed in Model Development				
Watershed	**Modeling Segment**	**Septic Systems**	**Houses on "Other Means"**	**Estimated Number of Houses with a Failing Sewage Disposal System (Failing Septic Systems and "Other Means")[1]**
Sugarland Run*	1	261	8	8
	2	174	6	5
	3	297	9	9
	4	215	7	7
	5	559	18	17
Mine Run	11	24	1	1
Pimmit Run	41	55	2	2
	42	122	5	4
	43	505	22	15
	44	22	1	1
	45	168	7	5
Total		**2,402**	**86**	**74**

[1]This is an estimate of failed systems by subwatershed calculated using an area-weighted method.

*For portions of Sugarland Run in Loudoun County, a septic failure rate of 2% was used.

3.8.3 Livestock

Livestock contribution to the total fecal coliform load in the watershed was represented in a number of ways, which are presented in **Figure 3-3**. The model accounts for fecal coliform directly deposited in the stream, fecal coliform deposited while livestock are in confinement and later spread onto the crop and pasture lands in the watershed (land application of manure), and finally, land-based fecal coliform deposited by livestock while grazing.

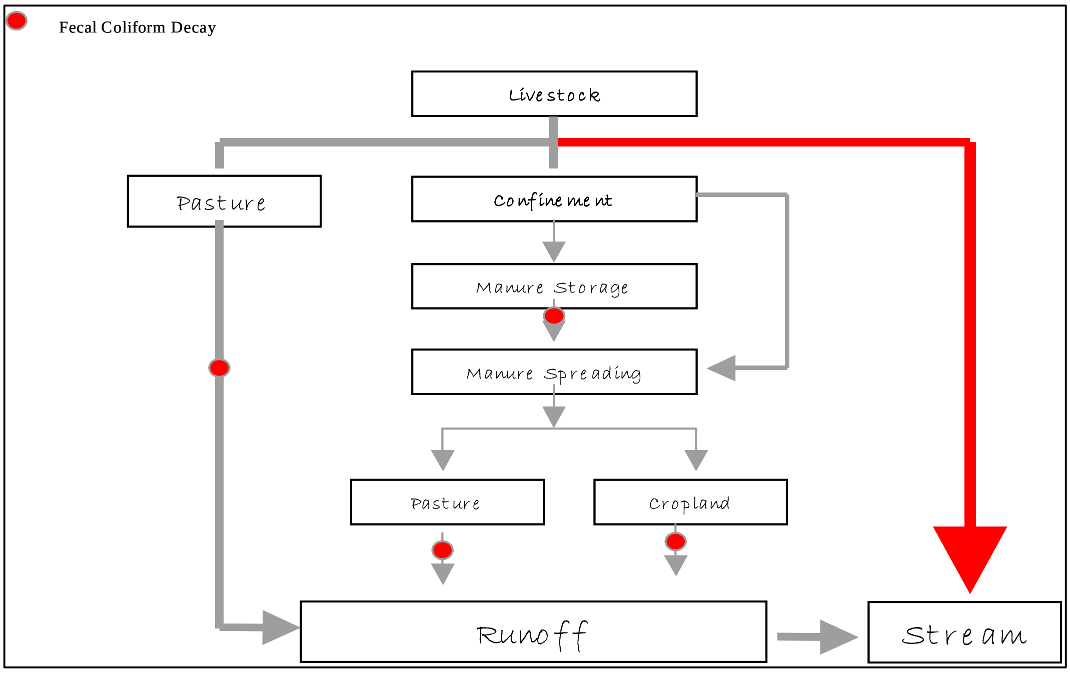


Figure 3-3: Livestock Contribution

Based on the inventory of livestock in the watershed, it was determined there were very few livestock in the Mine Run and Pimmit Run watersheds, and only slightly more in the Sugarland Run watershed. Horses were the dominant source of livestock in all three watersheds. Beef cattle were also present in the Sugarland Run watershed.

The distribution of the daily fecal coliform load between direct instream and indirect (land-based) loading was based on livestock daily schedules. The direct deposition load from livestock was estimated from the number of livestock in the watershed, the daily fecal coliform production per animal, and the amount of time livestock spent in the stream. The amount of time livestock spend in the stream was presented in Section 2.5.3.

The land-based load of fecal coliform from livestock while grazing was determined based on the number of livestock in the watershed, the daily fecal coliform production per animal, and the percent of time each animal spends in pasture. The monthly loading rates are presented in **Appendix B.**

3.8.4 Land Application of Manure

Beef cattle are present in the watershed. Because there are no feedlots or large manure storage facilities present in the watershed, the daily produced manure is applied to pastureland in the watershed, and was treated as an indirect source in the development of the TMDLs. Beef cattle spend the majority of their time on pastureland and are not confined. Thus, fecal coliform loading from beef cattle was accounted for via the methods described above. There are no dairy cattle in the watersheds. Horse manure was treated in the same manner as beef cattle manure.

3.8.5 Wildlife

Fecal coliform loading from wildlife was estimated in the same way as loading from livestock. As with livestock, fecal coliform contributions from wildlife can be both indirect and direct. The distribution between direct and indirect loading was based on estimates of the amount of time each type of wildlife spends on the surrounding land versus in the stream.

Daily fecal coliform production per animal and the amount of time each type of wildlife spends in the stream was presented in the wildlife inventory (**Table 2-20**). The direct wildlife fecal coliform load was calculated by multiplying the number of each type of wildlife in the watershed by the fecal coliform production per animal per day, and by the percentage of time each animal spends in the stream. The indirect (land-based) wildlife fecal coliform loading was estimated as the product of the wildlife density in each land use category or stream buffer (**Table 2-18**) and the daily fecal coliform production per wildlife animal. In summary, the indirect wildlife fecal coliform load is distributed on all land uses categories including the urban areas (High, Medium, and Low Intensity developed areas as well as the Developed Open Space land use category).

3.8.6 Pets

Pet fecal coliform loading was considered a land-based load that was primarily deposited in developed land within the watershed. The daily fecal coliform loading was calculated as the product of the number of pets in the watershed and the daily fecal coliform production per type of pet. The bacteria pet loading was distributed to all urban land uses including the Developed Open Space land use category. The pet loading was distributed proportionally using the number of houses within each land use category. Since there are no houses in the Developed Open Space land use category that can be used as a basis for the estimation of the pet bacteria loading, it was assumed that dog owners walk their dogs 40% of the time in the Open Space land use category. Therefore, the Developed Open Space land use category received 40% of all the pet loads in the watershed. This 40% assumption is conservative, since a survey of dog owners in the Chesapeake Bay indicates that 56% of dog owners walk their dog (Swann, 1999). The estimated bacteria pet loading on each urban land use category was then reduced by 50%, assuming that that pet owners pick up after their dogs 50% of the time (Swann, 1999).

3.9 Fecal Coliform Die-off Rates

Representative fecal coliform decay rates were included in the HSPF model developed for the watershed. Three fecal coliform die-off rates required by the model to accurately represent watershed conditions included:

1. **In-storage fecal coliform die-off**: Fecal coliform concentrations are reduced while manure is in storage facilities.

2. **On-surface fecal coliform die-off**: Fecal coliform deposited on the land surfaces undergoes decay prior to being washed into streams.

3. **Instream fecal coliform die-off**: Fecal coliform directly deposited into the stream, as well as fecal coliform entering the stream from indirect sources, will also undergo decay.

For the TMDL, in-storage die-off was not included in the model because there is no manure storage facility located in the watershed. Decay rates of 1.37 and 1.152 per day were used to estimate die-off rates for on surface and instream fecal coliform, respectively (EPA, 1985).

3.10 Model Set-up, Calibration, and Validation

Hydrologic calibration of the HSPF model involves the adjustment of model parameters to control various flow components (e.g. surface runoff, interflow and base flow, and the shape of the hydrographs) and make simulated values match observed flow conditions during the desired calibration period.

The model credibility and stakeholder faith in the outcome hinges on developing a model that has been calibrated and validated. Model calibration is a reality check. The calibration process compares the model results with observed data to ensure the model output is accurate for a given set of conditions. Model validation establishes the credibility of the model. The validation process compares the model output to the observed data set, which is different from the one used in the calibration process, and estimates the prediction accuracy of the model. Water quality processes were calibrated following calibration of the hydrologic processes of the model.

3.10.1 Model Set-Up

The HSPF model was set up and calibrated based on flow data taken at Difficult Run (USGS 01646000 – Difficult Run near Great Falls, VA). The calibration station is presented in **Table 3-6**.

Table 3-6: USGS Flow Stations used for Hydrology Calibration and Validation

Station ID	Station Name	Drainage Area (mi^2)	Begin Date	End Date
01646000	Difficult Run near Great Falls, VA	57.8	04/01/1935	10/19/2011

3.10.1.1 Stream Flow Data

The Difficult Run (USGS 01646000-Difficult Run near Great Falls, VA) flow station was selected because of its vicinity to the hydrologic modeling area. A 5-year period (2002-2006) was selected as the calibration period for the hydrologic model. The validation period selected was from 2007 to 2010. Observed flow data for the period of 1999 to 2010 for this station is plotted in **Figure 3-4**. The flow station is depicted in **Figure 3-2**.

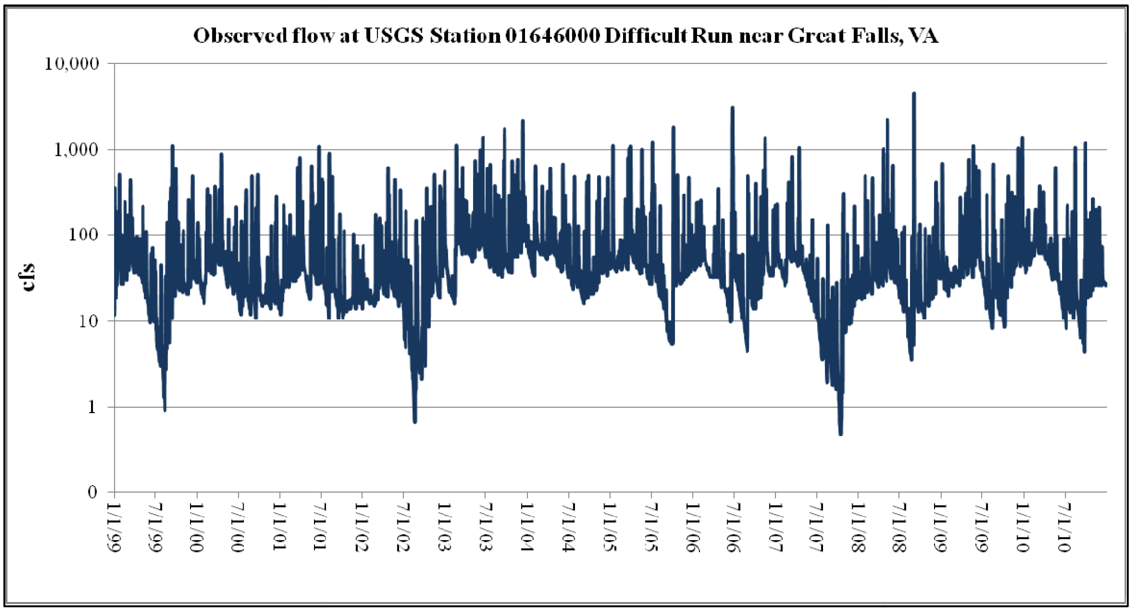


Figure 3-4: Observed Flow at USGS Station 01646000 (Difficult Run near Great Falls, VA) from 1999 to 2010

3.10.1.2 Rainfall and Climate Data

Weather data from the Reagan National Airport station was obtained from the National Climatic Data Center (NCDC). The data include meteorological (hourly precipitation) and surface airways data (including wind speed/direction, ceiling height, dry bulb temperature, dew point temperature, and solar radiation).

3.10.2 Model Hydrologic Calibration Results

The Expert System for Calibration of the Hydrological Simulation Program-FORTRAN (HSPEXP) software was used to calibrate the hydrology of the watershed. After each iteration of the model, summary statistics were calculated to compare model results with observed values, in order to provide guidance on parameter adjustment according to built-in rules. The rules were derived from the experience of expert modelers and listed in the HSPEXP user manual (Lumb and Kittle, 1993).

Using the recommended default criteria as target values for an acceptable hydrologic calibration, the hydrologic model was calibrated from January 2002 to December 2006 at the flow station. Calibration results are presented in **Table 3-7**, showing the simulated and observed values for eight flow characteristics. An error statistics summary for five flow conditions is presented in **Table 3-8**. The model results and the observed daily average flow at the calibration station are plotted in **Figure 3-5**. The cumulative flow frequency distribution curve is presented in **Figure 3-6**.

Table 3-7: Model Calibration Results

Category	Simulated	Observed
Total runoff, in inches	103.9	95.7
Total of highest 10% flows, in inches	47.72	47.27
Total of lowest 50% flows, in inches	14.57	15.04
Total storm volume, in inches	5.070	4.112
Baseflow recession rate	0.940	0.950
Summer flow volume, in inches	27.450	23.596
Winter flow volume, in inches	27.530	23.242
Summer storm volume, in inches	0.550	0.441

Table 3-8: Model Calibration Error Statistics		
Category	**Current**	**Criterion**
Error in total volume	8.6	+ 10.000
Error in low flow recession	0.010	+ 0.010
Error in 50% lowest flows	-3.100	+ 10.000
Error in 10% highest Flow	1.000	+ 15.000
Seasonal volume error	2.100	+ 10.000

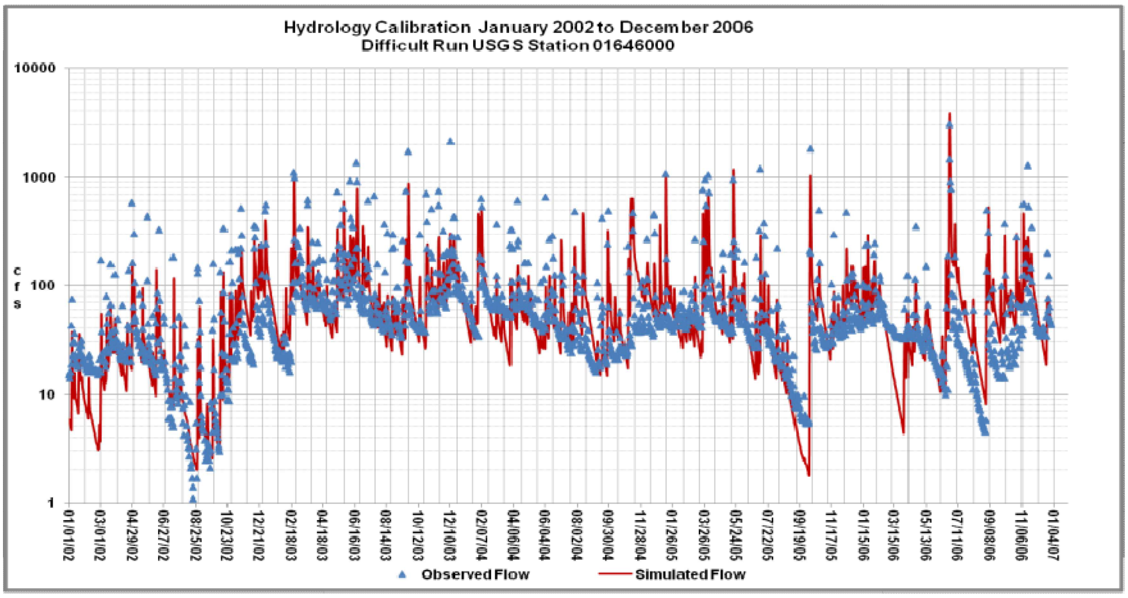


Figure 3-5: Observed and Calibrated Flow at USGS Station 01646000 (Difficult Run near Great Falls, VA)

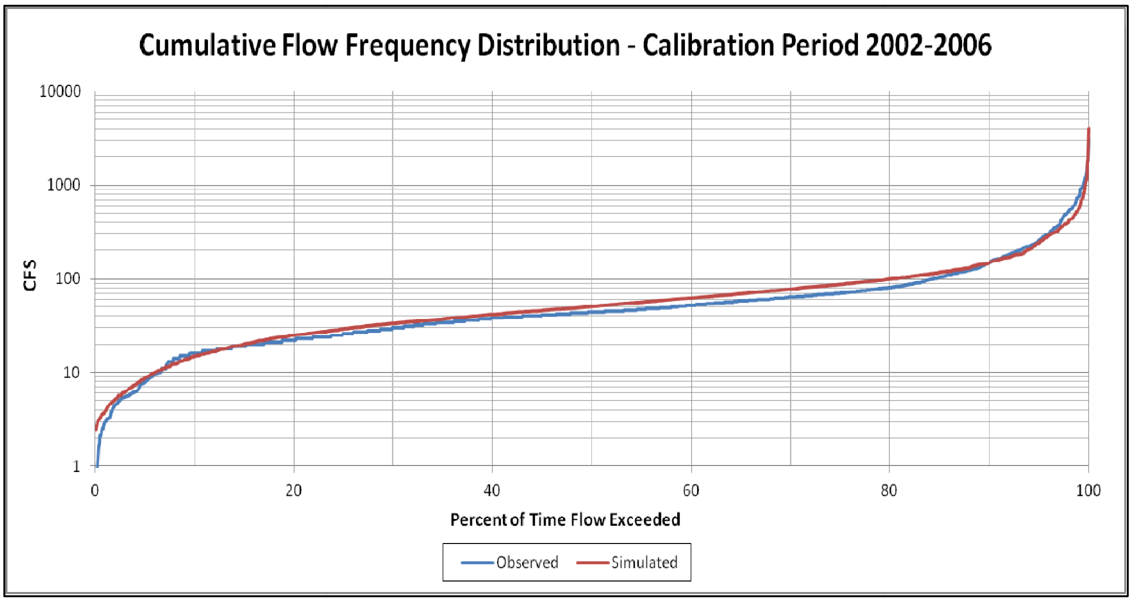


Figure 3-6: Cumulative Flow Frequency Distribution at USGS Station 01646000 (Difficult Run near Great Falls, VA) for Calibration Period

3.10.3 Model Hydrologic Validation Results

The period of January 2007 to December 2010 was used to validate the HSPF model. Model validation results are presented in **Table 3-9**, showing the simulated and observed values for seven flow characteristics. An error statistics summary for five flow conditions is also presented for this station in **Table 3-10**. The error statistics indicate that the validation results were within the recommended ranges in HSPF. The hydrology validation results for the model are plotted in **Figure 3-7**. The cumulative flow frequency distribution curve is presented in **Figure 3-8**.

Table 3-9: Model Validation Results Model Validation Results

Category	Simulated	Observed
Total runoff, in inches	48.680	44.792
Total of highest 10% flows, in inches	22.920	24.343
Total of lowest 50% flows, in inches	5.410	5.900
Total storm volume, in inches	4.720	3.866
Baseflow recession rate	0.940	0.930
Summer flow volume, in inches	8.260	8.054
Winter flow volume, in inches	11.780	11.0007
Summer storm volume, in inches	4.690	4.021

Table 3-10: Model Validation Results Model Validation Error Statistics

Category	Current	Criterion
Error in total volume	8.700	± 10.000
Error in low flow recession	-0.010	± 0.010
Error in 50% lowest flows	-8.300	± 10.000
Error in 10% highest Flow	-5.800	± 15.000
Seasonal volume error	4.400	± 10.000

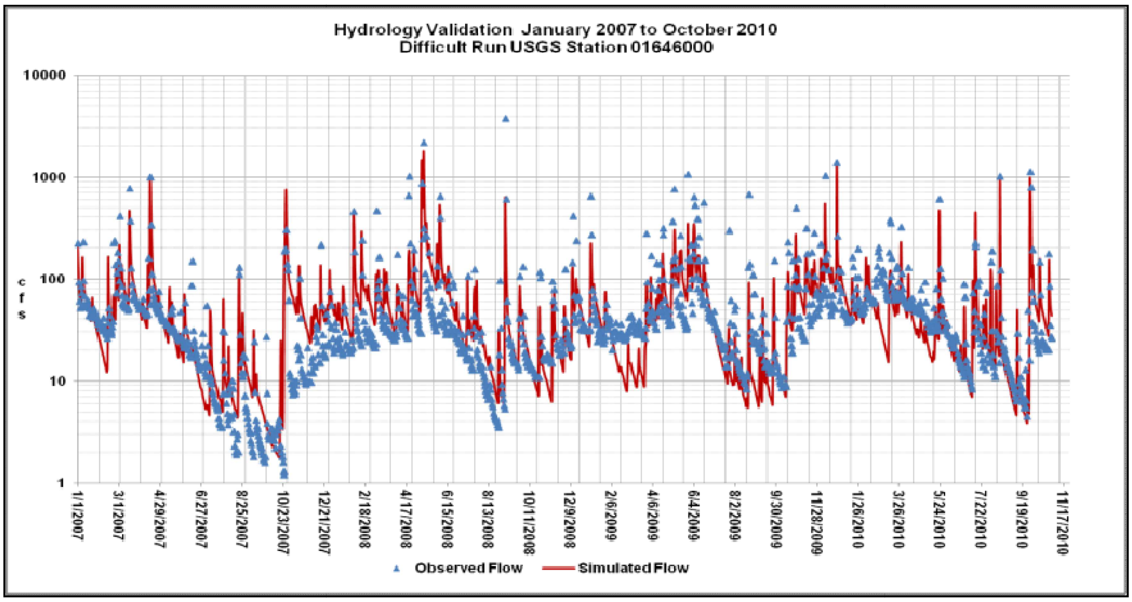


Figure 3-7: Observed and Validated Flow at USGS Station 01646000 (Difficult Run near Great Falls, VA)

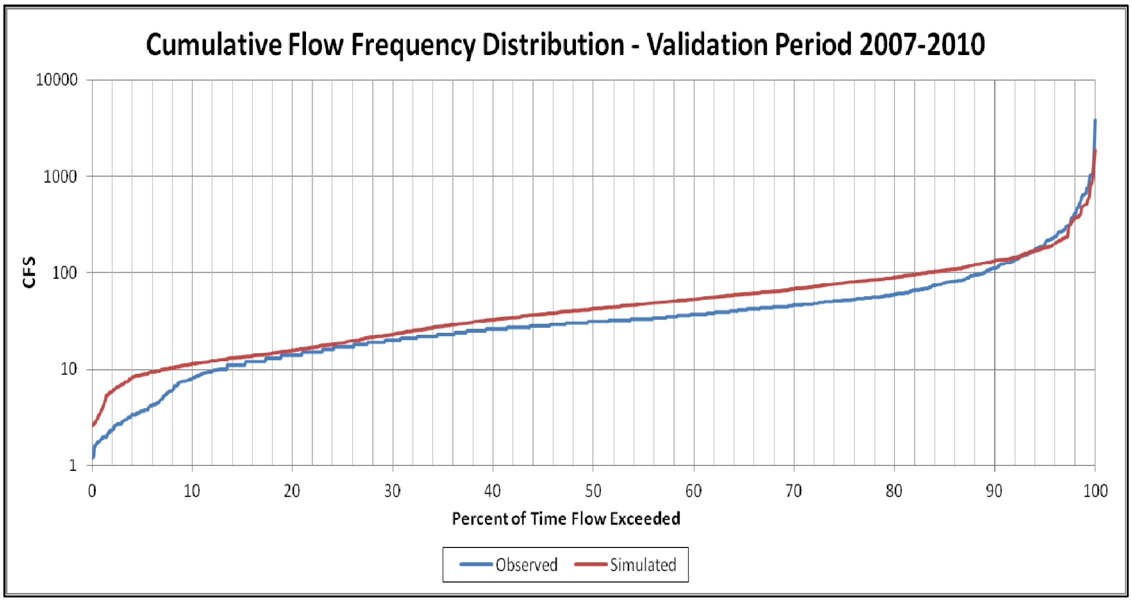


Figure 3-8: Cumulative Flow Frequency Distribution at USGS Station 01646000 (Difficult Run near Great Falls, VA) for Validation Period

There is good agreement between the observed and simulated stream flow, indicating that the model parameterization is representative of the hydrologic characteristics of the watershed. Model results closely match the observed flows during low flow conditions, base flow recession, and storm peaks. The final parameter values of the calibrated hydrology model are listed in **Table 3-11**.

Table 3-11: Sugarland Run, Mine Run, and Pimmit Run HSPF Calibration Parameters (Typical, Possible and Final Values)

Parameter	Definition	Units	Typical		Possible		Sugarland Run, Mine Run, and Pimmit Run
			Min	Max	Min	Max	
FOREST	Fraction forest cover	None	0.00	0.5	0	1.0	0
LZSN	Lower zone nominal soil moisture	inch	3	8	0.01	100	7.5 – 8.0
INFILT	Index to infiltration capacity	Inch/hour	0.01	0.25	0.0001	100	0.07 - 0.17
LSUR	Length of overland flow	Ft	200	500	1	None	300
SLSUR	Slope of overland flowpath	None	0.01	0.15	0.00001	10	0.008
KVARY	Groundwater recession variable	1/inch	0	3	0	None	0
AGWRC	Basic groundwater recession	None	0.92	0.99	0.001	0.999	0.910 – 0.935
PETMAX	Air temp below which ET is reduced	Deg F	35	45	None	None	40
PETMIN	Air temp below which ET is set to zero	Deg F	30	35	None	None	35
INFEXP	Exponent in infiltration equation	None	2	2	0	10	2
INFILD	Ratio of max/mean infiltration capacities	None	2	2	1	2	2
DEEPER	Fraction of groundwater inflow to deep recharge	None	0	0.2	0	1.0	0.1
BASETP	Fraction of remaining ET from base flow	None	0	0.05	0	1.0	0.00
AGWETP	Fraction of remaining ET from active groundwater	None	0	0.05	0	1.0	0
CEPSC	Interception storage capacity	Inch	0.03	0.2	0.00	10.0	0.06
UZSN	Upper zone nominal soil moisture	inch	0.10	1	0.01	10.0	0.50

Table 3-11: Sugarland Run, Mine Run, and Pimmit Run HSPF Calibration Parameters (Typical, Possible and Final Values)

NSUR	Manning's n	None	0.15	0.35	0.001	1.0	0.10 - 0.35
INTFW	Interflow/surface runoff partition parameter	None	1	3	0	None	3.00 – 4.00
IRC	Interflow recession parameter	None	0.5	0.7	0.001	0.999	0.30
LZETP	Lower zone ET parameter	None	0.2	0.7	0.0	0.999	0.2 – 0.55
ACQOP*	Rate of accumulation of constituent	#/ac day					3.47E06 - 1.64E09
SQOLIM*	Maximum accumulation of constituent	#					6.23E06 – 2.95E09
WSQOP*	Wash-off rate	Inch/hour					0.45 - 1.00
IOQC*	Constituent concentration in interflow	#/CF					1416
AOQC*	Constituent concentration in active groundwater	#/CF					283
KS*	Weighing factor for hydraulic routing		0.5				0.5
FSTDEC*	First order decay rate of the constituent	1/day	1.152 (FC)				1.152
THFST*	Temperature correction coefficient for FSTDEC	none	1.07				1.07

*Typical values these parameters are unavailable because they are site-specific and determined through model calibration.

3.10.4 Water Quality Calibration

Calibrating the water quality component of the HSPF model involves setting up the build-up, wash-off, and kinetic rates for fecal coliform bacteria that best describe fecal coliform sources and environmental conditions in the watershed. It is an iterative process in which the model results are compared to the available instream fecal coliform data, and the model parameters are adjusted until there is an acceptable agreement between the observed and simulated instream concentrations and the build-up and wash-off rates are within the acceptable ranges.

The availability of water quality data is a major factor in determining calibration and validation periods for the model. In Section 2.3, instream monitoring stations on the impaired segments were listed and sampling events conducted on Sugarland Run, Mine Run, and Pimmit Run were summarized and presented. **Table 3-12** lists the stations used in the water quality calibration for each impaired segment.

Table 3-12: Water Quality Stations used in the HSPF Fecal Coliform Simulations

Stream	Water Quality Station	HSPF Model Segment
Sugarland Run	1ASUG004.42	3
Mine Run	1AMNR000.72	11
Pimmit Run	1APIM004.16	43
Pimmit Run	1APIM000.15	41

The period used for water quality calibration of the model, and the period used for model validation depended on the time the water quality observations were collected. In fact, the observed *E. coli* concentrations are instantaneous values that are highly dependent on the time and location the sample was collected. The model-simulated fecal coliform concentrations represent the average daily values. The simulated *E. coli* concentrations were derived from the simulated fecal coliform concentrations using a regression-based instream translator, which is presented below:

$$E.\ coli\ concentration\ (cfu/100\ ml) = 2^{-0.0172} \times (FC\ concentration\ (cfu/100ml))^{0.91905}$$

Figures 3-9, **3-10**, **3-11** and **3-12** depict the simulated water quality at Sugarland Run, Mine Run, and Pimmit Run.

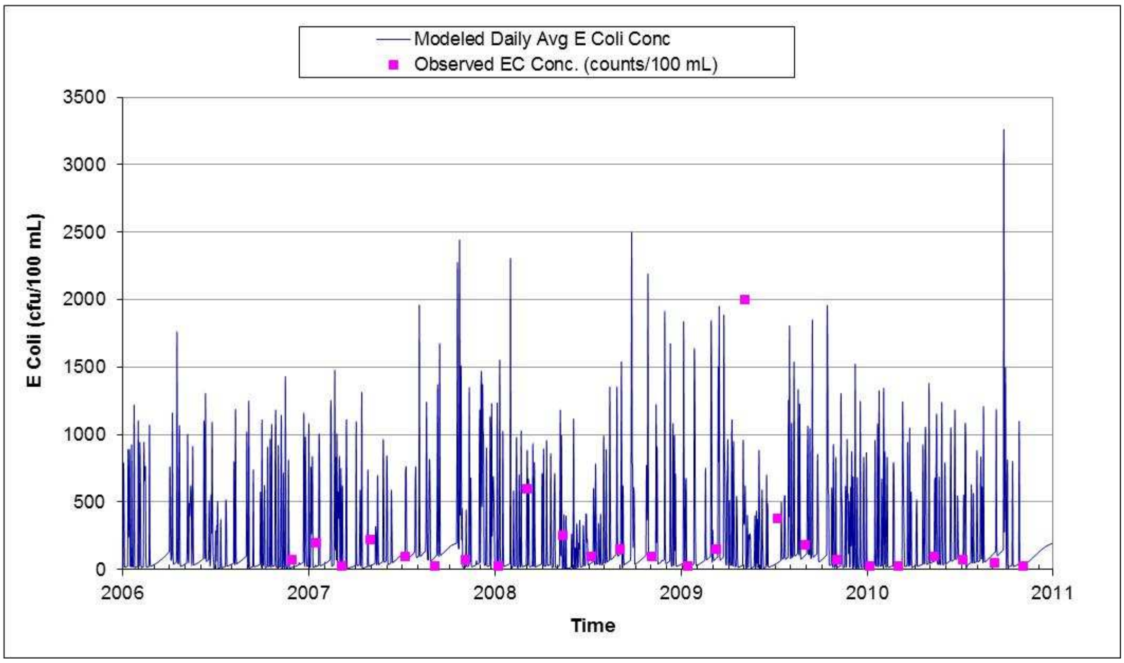


Figure 3-9: *E. coli* Calibration Sugarland Run – 1aSUG004.42

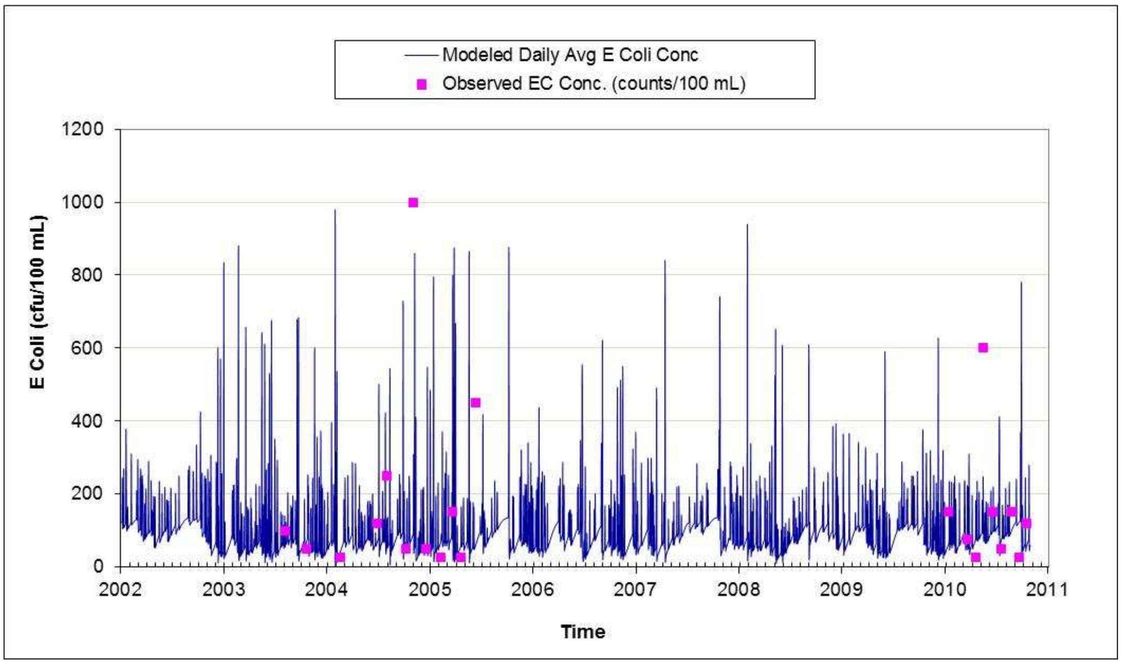


Figure 3-10: *E. coli* Calibration Mine Run – 1aMNR000.72

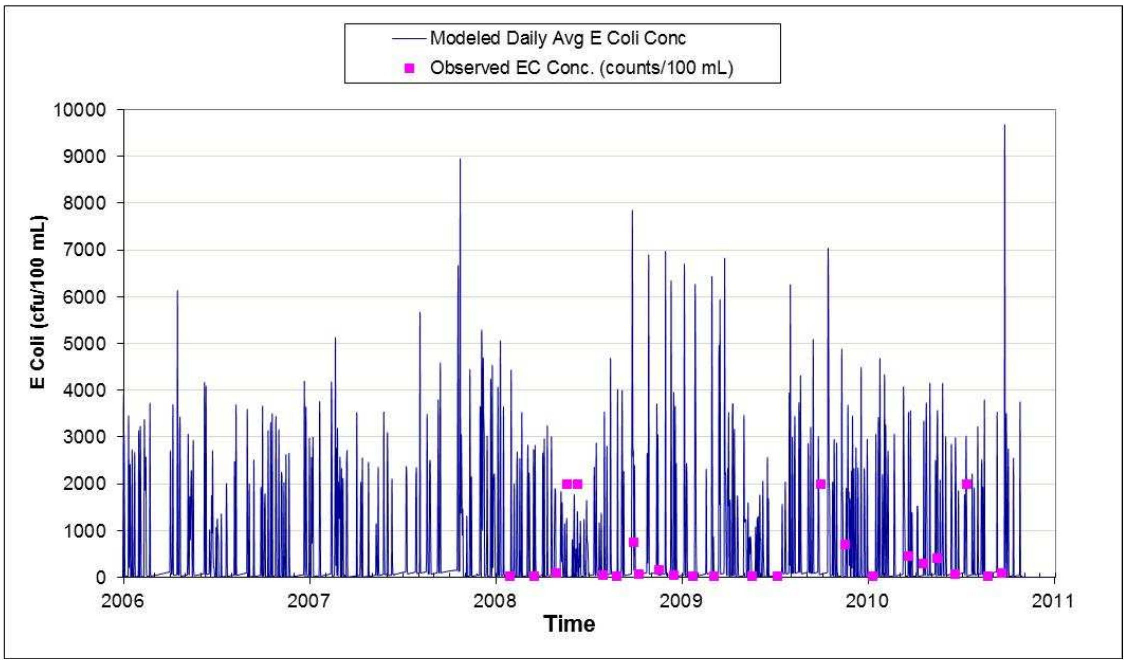


Figure 3-11: *E. coli* Calibration Pimmit Run – 1aPIM000.15

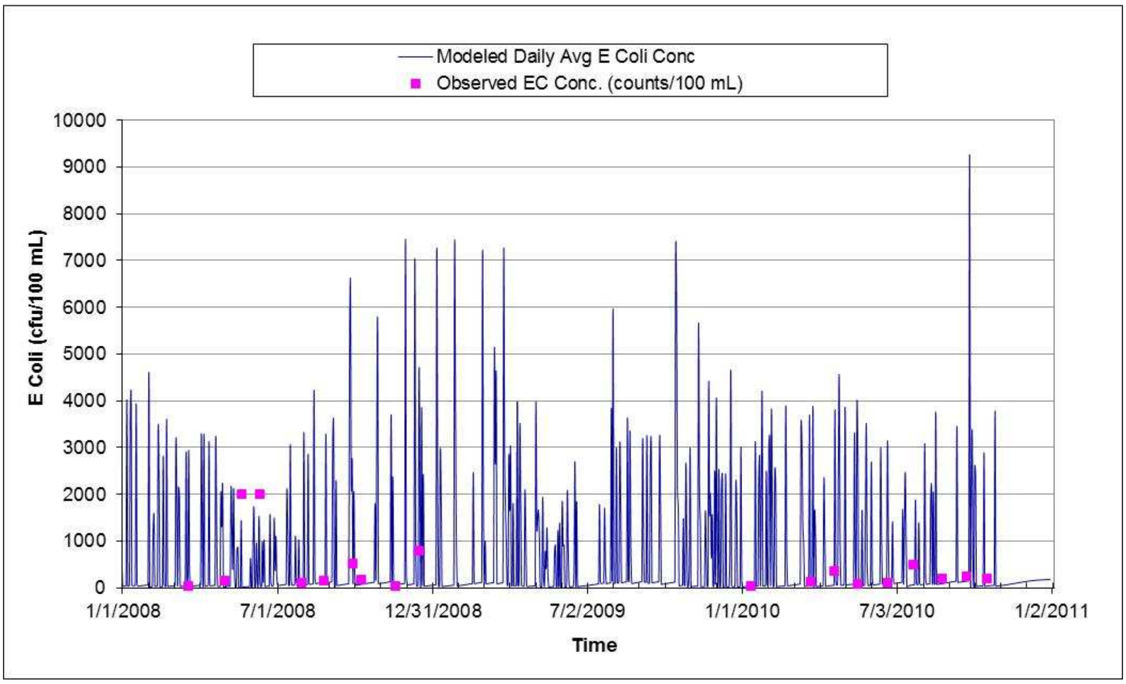


Figure 3-12: *E. coli* Calibration Pimmit Run – 1aPIM004.16

The goodness of fit for the water quality calibration was evaluated visually. Analysis of the model results indicated that the model was capable of predicting the range of *E. coli* concentrations under both wet and dry weather conditions, and thus was well-calibrated. **Table 3-13** shows the observed and simulated geometric mean *E. coli* concentration spanning the period from 2002 to 2010. **Table 3-14** shows the observed and simulated exceedance rates of the 235 cfu/100 ml maximum *E. coli* standard spanning the period from 2002 to 2010.

Table 3-13: Observed and Simulated Geometric Mean *E. coli* Concentration (2002-2010)

Station	Reach	Geometric Mean	
		Simulated	Observed
Sugarland Run - 1ASUG004.42	3	80	96
Mine Run - 1AMNR000.72	11	81	93
Pimmit Run - 1APIM000.15	41	101	127
Pimmit Run - 1APIM004.16	43	119	188

Table 3-14: Observed and Simulated Exceedance Rates of the 235 cfu/100 mL Maximum *E. coli* Criterion (2002-2010)

Station	Reach	Exceedances of the Instantaneous Standard	
		Simulated	Observed
Sugarland Run - 1ASUG004.42	3	28%	19%
Mine Run - 1AMNR000.72	11	22%	19%
Pimmit Run - 1APIM000.15	41	27%	36%
Pimmit Run - 1APIM004.16	43	26%	37%

3.11 Existing Bacteria Loading

The existing fecal coliform loading for the watershed was calculated based on current watershed conditions. Model input parameters reflected conditions during the period of 2002 to 2010. The standards used for fecal coliform concentrations were a geometric mean criterion of 200 cfu/100 mL and a maximum criterion of 400 cfu/100 mL. For *E. coli* concentrations, the criteria used were a geometric mean of 126 cfu/100 mL and a maximum assessment criterion of 235 cfu/100 mL (VADEQ, 2006). The *E. coli* concentrations in the impaired segments were calculated from fecal coliform concentrations using the previously presented regression based instream translator.

3.11.1 Sugarland Run

The instream concentrations of bacteria under existing conditions in the Sugarland Run mainstem are above the *E. coli* geometric mean a number of times during the simulation period and above the *E. coli* maximum criteria for the majority of the time period. **Figure 3-13** shows the modeled *E. coli* monthly geometric mean concentrations under existing conditions and **Figure 3-14** shows the modeled daily *E. coli* concentrations under existing conditions.

Distribution of the existing *E. coli* load by source in Sugarland Run (Segments VAN-A10R_SUG01A00 and VAN-A10R_SUG01B06) is presented in **Table 3-15**. *E. coli* concentrations in the impaired Sugarland Run segments were calculated from fecal coliform concentrations using the instream translator. **Table 3-15** shows that runoff loading from residential areas (which includes the bacteria loads from pets and wildlife) is the predominant source of bacteria in the Sugarland Run watershed. However, both wet weather and dry weather conditions were identified as critical conditions. Under wet weather conditions, the indirect deposition loads from pets and wildlife in residential areas will dominate. Under dry weather conditions, the direct deposition loads from wildlife could dominate.

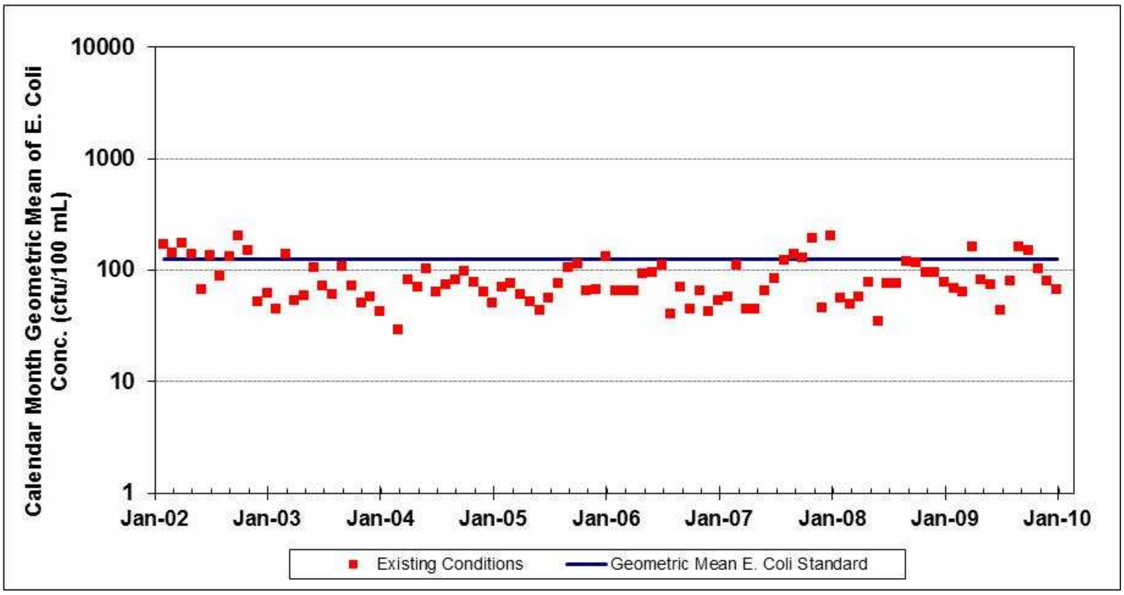


Figure 3-13: Modeled Monthly *E. coli* Geometric Mean Under Existing Conditions for Sugarland Run

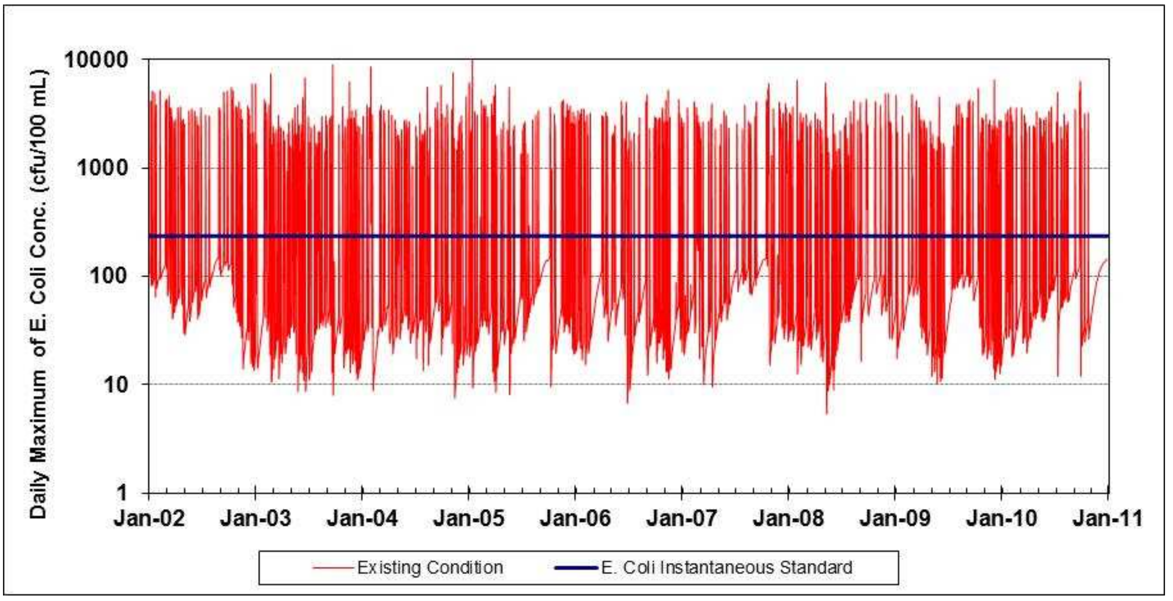


Figure 3-14: Modeled Daily *E. coli* Concentrations under Existing Conditions for Sugarland Run.

Table 3-15: Sugarland Run *E. coli* Existing Load Distribution

Source	Annual Average *E. Coli* Loads	
	cfu/year	%
Forest	2.53E+12	1.2
Cropland	7.36E+09	<0.1
Pasture	1.19E+12	0.6
Urban – Developed Land*	2.05E+14	95.9
Cattle Direct Deposition	1.18E+11	0.1
Wildlife Direct Deposition	3.99E+12	1.9
Failing Septics	8.91E+11	0.4
Point Sources	1.74E+09	<0.1
SSOs	**7.77E+07**	<0.1
Total	**2.14E+14**	**100.0**

*Loads from pets and wildlife

3.11.2 Mine Run

The instream concentrations of bacteria under existing conditions in the Mine Run mainstem are above the *E. coli* geometric mean a number of times during the simulation period and above the *E. coli* maximum criteria for the majority of the time period. **Figure 3-15** shows the modeled monthly *E. coli* geometric mean concentrations under existing conditions and **Figure 3-16** shows the daily *E. coli* concentrations under existing conditions.

Distribution of the existing *E. coli* load by source in Mine Run (Segment VAN-A11R_MNR01A04) is presented in **Table 3-16**. *E. coli* concentrations in the impaired Mine Run segment were calculated from fecal coliform concentrations using the instream translator. **Table 3-16** shows that runoff loading from residential areas (which includes the bacteria loads from pets and wildlife) as well as direct deposition wildlife loading are the predominant sources of bacteria in the Mine Run watershed. Both wet weather and dry weather conditions were identified as critical conditions. Under wet weather conditions, the indirect deposition loads from pets and wildlife in residential areas will dominate. Under dry weather conditions, the direct deposition loads from wildlife will dominate.

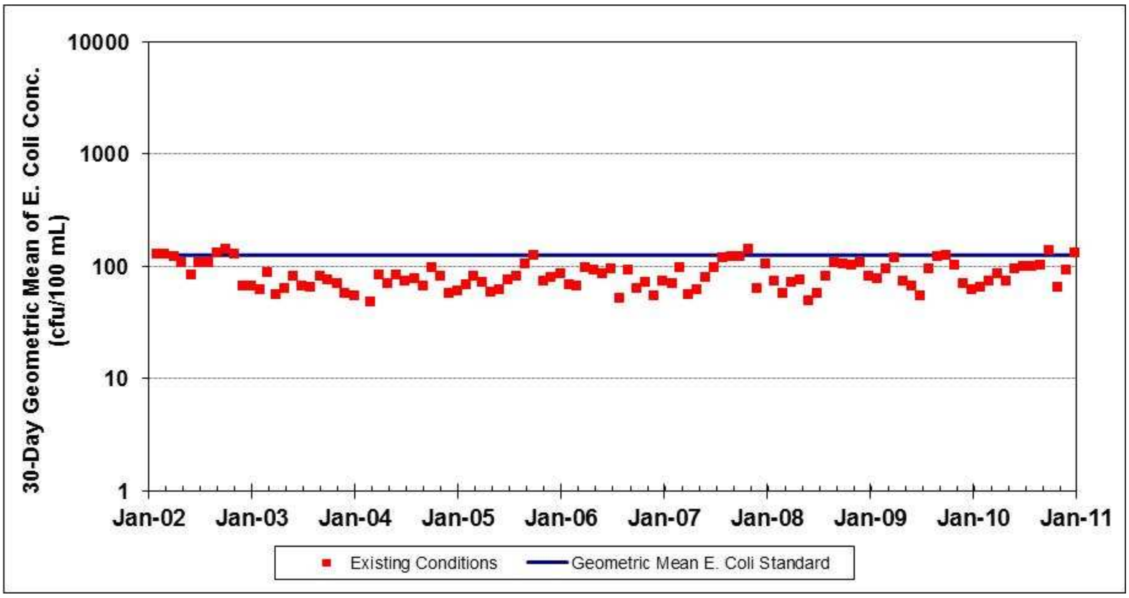


Figure 3-15: Modeled Monthly *E. coli* Geometric Mean for Mine Run under Existing Conditions

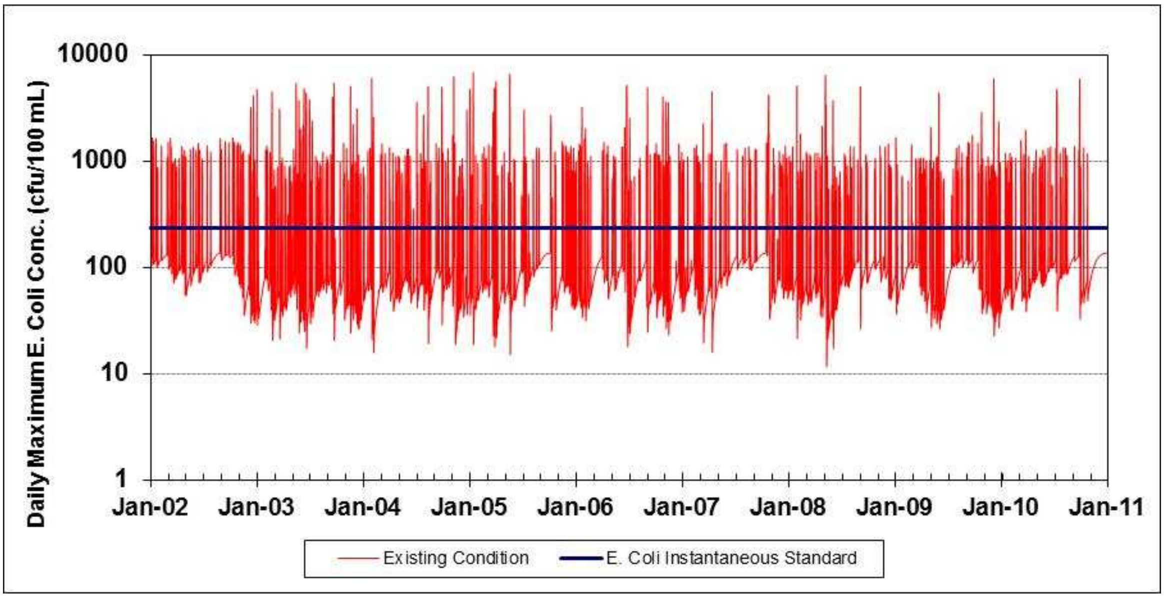


Figure 3-16: Modeled Daily *E. coli* Concentrations for Mine Run under Existing Conditions

Table 3-16: Mine Run *E. coli* Existing Load Distribution		
	Annual Average *E. Coli* Loads	
Source	**cfu/year**	**%**
Forest	3.39E+11	2.8
Cropland	8.82E+09	0.1
Pasture	9.63E+10	0.8
Urban – Developed Land*	9.51E+12	78.1
Cattle Direct Deposition	0.00E+00	0.0
Wildlife Direct Deposition	2.21E+12	18.1
Failing Septics	2.21E+10	0.2
Point Sources	0.00E+00	0.0
SSOs	0.00E+00	0.0
Total	**1.22E+13**	**100.0%**
*Loads from pets and wildlife		

3.11.3 Pimmit Run

The instream concentrations of bacteria under existing conditions in the Pimmit Run mainstem are above the *E. coli* geometric mean a number of times during the simulation period and above the *E. coli* maximum criteria for the majority of the time period. **Figure 3-17** shows the modeled monthly *E. coli* geometric mean concentrations under existing conditions and **Figure 3-18** shows the modeled daily *E. coli* concentrations under existing conditions.

Distribution of the existing *E. coli* load by source in Pimmit Run (Segments VAN-A12R_PIM02A00, VAN-A12R_PIM01A00 and VAN-A12R_PIM02B06) is presented in **Table 3-17**. *E. coli* concentrations in the impaired Pimmit Run segment were calculated from fecal coliform concentrations using the instream translator. **Table 3-17** shows that loading from residential areas (which includes the bacteria loads from pets and wildlife) is the predominant source of bacteria in the Pimmit Run watershed. Both wet weather and dry weather conditions were identified as critical conditions. Under wet weather conditions, the indirect deposition loads from pets and wildlife in residential areas will dominate. Under dry weather conditions, the direct deposition loads from wildlife could dominate.

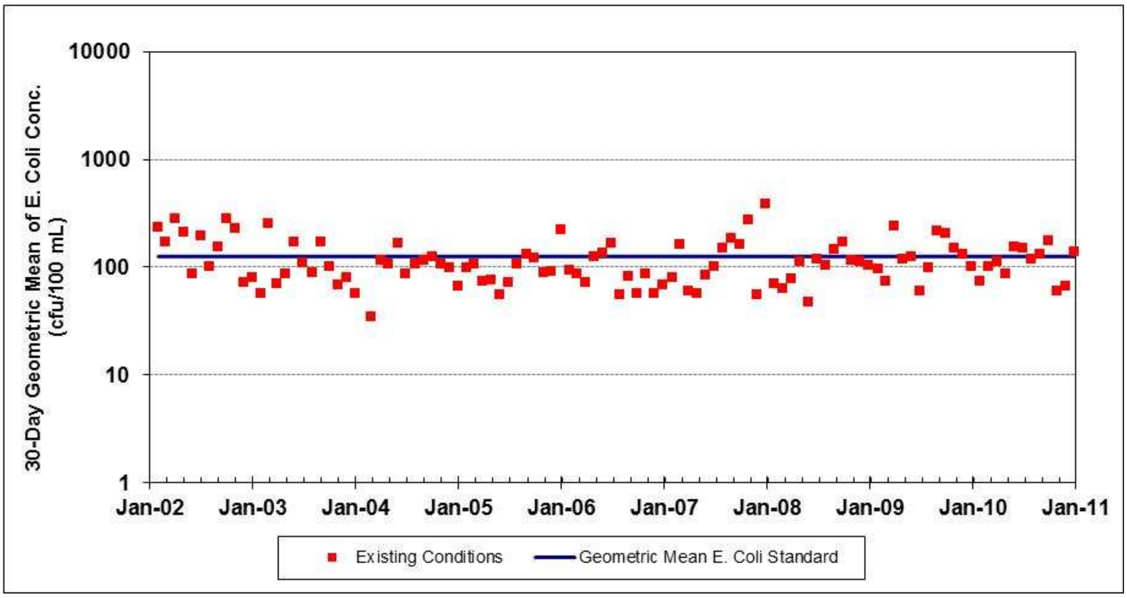


Figure 3-17: Modeled Monthly *E. coli* Geometric Means for Pimmit Run under Existing Conditions

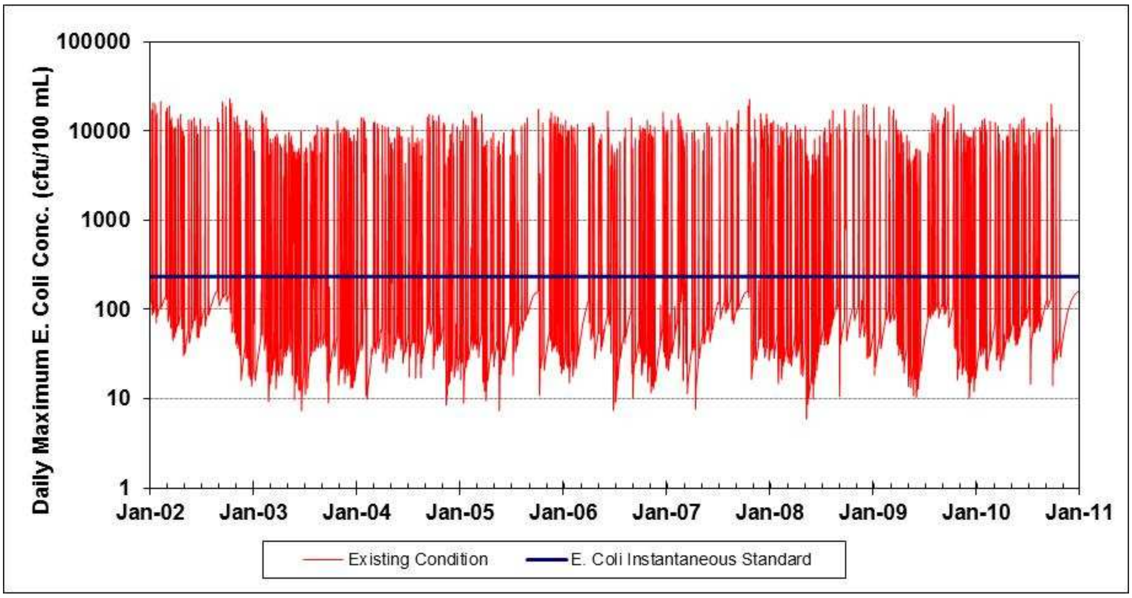


Figure 3-18: Modeled Daily *E. coli* Concentrations for Pimmit Run under Existing Conditions

Table 3-17: Pimmit Run *E. coli* Existing Load Distribution

Source	Annual Average *E. Coli* Loads	
	cfu/year	**%**
Forest	1.35E+12	0.5
Cropland	3.08E+09	<0.1
Pasture	2.68E+11	0.1
Urban – Developed Land*	2.40E+14	97.9
Cattle Direct Deposition	0.00E+00	0.0
Wildlife Direct Deposition	3.08E+12	1.3
Failing Septics	5.30E+11	0.2
Point Sources	0.00E+00	0.0
SSOs	1.28E+10	<0.1
Total	**2.45E+14**	**100.0%**

*Loads from pets and wildlife

4.0 Allocation

Allocation analysis was the third stage in the development of the Sugarland Run, Mine Run and Pimmit Run TMDLs. The purpose of this third stage was to develop the framework for reducing bacteria loadings under the existing watershed conditions so that water quality standards may be met. The TMDLs represent the maximum amount of pollutant that the stream can receive without exceeding the water quality criteria. The load allocations for the selected scenarios were calculated using the following equation:

$$TMDL = \sum WLA + \sum LA + MOS$$

Where,

WLA = waste load allocation (point source contributions);

LA = load allocation (nonpoint source allocation); and

MOS = margin of safety.

Typically, several potential allocation strategies would achieve the TMDL endpoint and water quality standards. Available control options depend on the number, location, and character of pollutant sources.

4.1 Incorporation of Margin of Safety

The margin of safety (MOS) is a required component of the TMDL to account for any lack of knowledge concerning the relationship between effluent limitations and water quality. According to EPA guidance (*Guidance for Water Quality-Based Decisions: The TMDL Process, 1991*), the MOS can be incorporated into the TMDL using two methods:

- Implicitly incorporating the MOS using conservative model assumptions to develop allocations; or
- Explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations.

The MOS will be implicitly incorporated into this TMDL. Implicitly incorporating the MOS will require that allocation scenarios be designed to meet the monthly geometric mean criterion of 126 cfu/100 mL for *E. coli* bacteria. In addition, it is required that final allocation scenarios be designed so that there is no more than a 10% exceedance rate of the maximum assessment criterion for *E. coli* of 235 cfu/100 mL.

4.2 Allocation Scenario Development

Allocation scenarios were modeled using the calibrated HSPF model to adjust the existing conditions until the water quality criteria were attained. The Sugarland Run, Mine Run, and Pimmit Run TMDLs were based on the Virginia water quality criteria for *E. coli*. As detailed in Section 1.3, the freshwater recreation use standard indicates that the calendar-month geometric mean concentration for *E. coli* bacteria shall not exceed 126 cfu/100 mL. The standards also indicate that in the event that insufficient data are available to calculate a geometric mean (in order to calculate a monthly geometric mean at least four weekly samples are required) then no more than 10% of the samples shall exceed the maximum assessment criterion of 235 cfu/100 mL for *E. coli* bacteria. According to the guidelines put forth by VADEQ (VADEQ, 2011) for modeling *E. coli* with HSPF, the model was set up to estimate loads of fecal coliform, and then the model output was converted to concentrations of *E. coli* with the following equation:

$$log_2EC\ (cfu/100mL) = -0.0172 + 0.91905 * log_2FC\ (cfu/100mL)$$

Where: EC = *E. coli* bacteria concentration
FC = Fecal coliform bacteria concentration

The pollutant concentrations were simulated over the entire duration of a representative modeling period, and pollutant loads were adjusted until the criteria was met. The pollutant loads were calculated at the outlet (furthest downstream point) of the impaired segments. The development of the allocation scenarios was an iterative process requiring numerous runs where each run was followed by an assessment of source reduction against the water quality target. The long-term average *E. coli* loads and coefficient of variations were determined to implement the final allocation scenarios and to express the TMDL on a daily basis. Assuming a log-normal distribution of data and a probability of occurrence of 95%, the maximum daily loads were determined using the following equation (*USEPA OWOW 2007 Options for Expressing Daily Loads in TMDLs*):

$$MDL = LTA \times Exp[z\sigma - 0.5\sigma^2]$$

Where;

MDL = maximum daily limit (cfu/day)

LTA = long-term average (cfu/day)

z = z statistic of the probability of occurrence

$\sigma^2 = \ln(CV^2+1)$

CV = coefficient of variation

Daily expressions for aggregate WLAs and LAs were calculated using the above method. The daily expression of individual WLAs, presented in **Tables 4-1 and 4-2**, were calculated based on the average annual individual WLAs divided by 365 days in a year. These daily average values are not intended to represent maximum allowable daily loads. Rather, they represent the average daily loadings that may be expected to occur over the long term.

The following sections present the waste load allocation (WLA) and load allocations (LA) for the impaired segments.

4.3 Wasteload Allocation

This section outlines the wasteload allocations (WLA) for each of the impaired watersheds. It presents the existing and allocated loads for each permitted (VPDES and MS4) facility contributing to the impaired segments. There may be other industrial process water and/or stormwater dischargers in the watershed that are authorized to discharge under the VPDES program. These facilities are not expected to discharge the pollutant of concern (bacteria). However, there may be incidental, insignificant levels of bacteria found in these discharges; the discharges are not considered to have a reasonable potential to cause or contribute to exceedances of the Virginia Water Quality Standards and the observed stream impairments. Any inadvertent bacteria discharge would be insignificant, and are not considered in this TMDL. Additionally, it should be noted that reported SSOs in any of the impaired watersheds were incorporated into the source inventory for model calibration. However, SSOs did not receive a wasteload allocation as they are unauthorized discharges.

For Sugarland Run, Mine Run, and Pimmit Run, an explicit allocation equivalent to 1% of the total TMDL for each of the watersheds was provided for future growth of permitted point sources in the watershed. The 1% of the total TMDL allocation for future growth in each watershed was determined to be sufficient to cover the estimated failing sewage disposal systems and straight pipes presented in Section 2.5.2. In cases where replacement septic systems or alternative systems are not suitable for failing sewage disposal systems and/or straight pipes, there is adequate future growth in each TMDL watershed to issue discharge permits as needed. In each of the TMDL watersheds, the future growth will be allocated to both new and existing permits as need on a first-come, first-serve basis thought the VADEQ VPDES permitting process. Allocation of bacteria loadings shall be determined at the discretion of DEQ staff.

4.3.1 Sugarland Run

There is one VPDES permitted facility which discharges into the Sugarland Run bacteria impaired watershed (General Permit for a Single Family Home: VAG406279). It has been assigned a waste load allocation equal to its maximum permitted design flow (0.001 MGD) multiplied by the geometric mean *E. coli* criterion of 126 cfu/100 mL and the appropriate conversion factors, resulting in a allocation of 1.74E+09 cfu/year. An additional allocation, equivalent to 1% of the total TMDL load for the watershed, was provided for the future growth of VPDES permitted point sources in the watershed. TMDL allocation plan for the VPDES permit in Sugarland Run is presented in **Table 4-1**.

Table 4-1: WLA for VPDES Permitted Facilities in the Sugarland Run Watershed

Permit Number	Facility Type	Design Flow (MGD)	Effluent Limit (cfu/100mL)	Wasteload Allocation (cfu/day)	Wasteload Allocation (cfu/year)
VAG406279	Residence	0.001	126	4.77E+06	1.74E+09
			Future Growth Allocation:	3.32E+08	1.21E+11
			Total WLA:	3.36E+08	1.23E+11

4.3.2 Mine Run

There are no municipal permitted facilities which discharge into the Mine Run bacteria impaired watershed. However, an explicit allocation (equivalent to 1% of the total TMDL load for the watershed) was provided for the future growth of VPDES permitted point sources in the watershed. The future growth allocation for VPDES point sources in the Mine Run watershed is 3.12E+10 cfu/year.

4.3.3 Pimmit Run

There are no municipal permitted facilities which discharge into the Pimmit Run bacteria impaired watershed. However, an explicit allocation (equivalent to 1% of the total TMDL load for the watershed) was provided for the future growth of VPDES permitted point sources in the watershed. The future growth allocation for VPDES point sources in the Pimmit Run watershed is 5.85E+10 cfu/year.

4.3.4 MS4 Allocation

As discussed in the earlier section, loads associated with MS4 areas are considered part of the wasteload allocation. Seven MS4 permits have been issued in the Sugarland Run, Mine Run, and Pimmit Run watersheds. For Phase I MS4 Permits (for example, Fairfax County), all land-based loadings from developed land use categories (high, medium, and low intensity developed land uses) within the impaired watersheds were allocated to the MS4 permits. For Phase II Permits (i.e. VDOT, Town of Herndon, etc.) all land-based loadings from developed land use categories (high, medium, and low intensity developed land use categories) within the most recent United States Census-defined urban areas of the permit boundaries were allocated to the MS4s. The most recent United States decennial census with defined urban areas is the 2010 Census. This approach for developing MS4 allocations is a land-use based approach.

One disadvantage to the land-use based approach is that it is not able to distinguish between urban areas that drain to regulated MS4s and those that drain to other unregulated pervious areas or directly to surface waters. At the time of TMDL development, detailed information regarding the portion of each watershed that drains to a MS4 system was not available, so a conservative, land-use based approach was used. It is important to note that the actual areas within the TMDL watersheds that are subject to a MS4 WLA are those areas that are specifically regulated under the MS4 permit. This TMDL study does not attempt or intend to define the MS4 regulatory area. Rather, the areas used to develop loadings associated with the MS4 permits in this TMDL (developed and Census defined urban areas) are only surrogates for establishing WLAs, estimating a reasonable pollutant loading that is expected to be contributed by these permitted sources. The WLAs for MS4 permittees can be revised in the future, as necessary, if additional information regarding the MS4 drainage areas becomes available or if adaptive management indicates that related loading(s) or reduction strategies would be impacted to a significant degree. Due to the spatial overlap between MS4 entities and the resulting uncertainty of the appropriate operator of the system, the MS4 loads are aggregated by jurisdiction (Town of Herndon and Fairfax, Loudoun, and Arlington Counties) in the TMDL. In most cases, the boundaries of MS4 areas are not available in enough geospatial detail to disaggregate the MS4 loads and assign individual Waste Load Allocations. EPA, DEQ, and DCR support the aggregation of MS4 WLAs for this reason. Additionally, aggregation encourages stakeholder cooperation for the implementation of appropriate BMPs to address reductions required by the TMDL.

The allocated *E. coli* load from MS4 sources in the Sugarland Run watershed is 4.65E+12 cfu/year; 9.12E+10 cfu/year in Mine Run; 1.12E+12 cfu/year in Pimmit Run. (**Table 4-2**).

Table 4-2: MS4 Wasteload Allocation for *E. coli*

Permit Number	MS4 Permit	MS4 Geographical Area	Developed Acres	Overall MS4 Allocation (cfu/year)	MS4 Allocation by Jurisdiction (cfu/day)	MS4 Allocation by Jurisdiction (cfu/year)
Sugarland Run (A10R-01-BAC)						
VA0088587	Fairfax County	Fairfax County	3,727	4.65E+12	5.50E+09	2.01E+12
VAR040104	Fairfax County Public Schools					
VAR040115	Virginia Department of Transportation					
VAR040067	Loudoun County	Loudoun County	3,267		4.82E+09	1.76E+12
VAR040115	Virginia Department of Transportation					
VAR040060	Town of Herndon	Town of Herndon	1,652		2.44E+09	8.89E+11
VAR040104	Fairfax County Public Schools					
VAR040115	Virginia Department of Transportation					
		Total MS4	**8,645**	**4.65E+12**	**1.28E+10**	**4.65E+12**
Mine Run (A11R-02-BAC)						
VA0088587	Fairfax County	Fairfax County	91	9.12E+10	2.50E+08	9.12E+10
VAR040104	Fairfax County Public Schools					
VAR040111	George Washington Memorial Parkway					
VAR040115	Virginia Department of Transportation					
		Total MS4	**91**	**9.12E+10**	**2.50E+08**	**9.12E+10**
Pimmit Run (A12R-02-BAC)						
VA0088587	Fairfax County	Fairfax County	3,230	1.12E+12	2.41E+09	8.80E+11
VAR040104	Fairfax County Public Schools					
VAR040111	George Washington Memorial Parkway					
VAR040115	Virginia Department of Transportation					
VA0088579	Arlington County	Arlington County	863		6.44E+08	2.35E+11
VAR040115	Virginia Department of Transportation					
VAR040111	George Washington Memorial Parkway					
		Total MS4	**4,092**	**1.12E+12**	**3.05E+09**	**1.12E+12**

4.4 Load Allocation Development

The reduction of loadings from non-point sources, including livestock and wildlife direct deposition, is incorporated into the load allocation. A number of load allocation scenarios were developed in order to determine the final TMDL load allocation. Fecal coliform loading and instream fecal coliform concentrations were estimated for each potential scenario using the HSPF model for the hydrologic period of January 2002 to December 2010. The following is a list of load allocation scenarios that were used to arrive at the final TMDL allocations. Additional scenarios deemed necessary were also run to attain the final TMDL. The following is a brief summary of the key scenarios:

- Scenario 0 is the existing load, no reduction of any of the sources.
- Scenario 1 represents elimination of human sources (failing sewage disposal systems).

- Scenario 2 represents the elimination of human sources (failing sewage disposal systems) as well as half the direct instream loading from livestock.
- Scenario 3 represents the elimination of the human sources (failing sewage disposal systems) as well as the direct instream loading from livestock.
- Scenario 4 represents the elimination of all non-point sources and direct instream loading from livestock.
- Scenario 5 represents the elimination of the human sources (failing sewage disposal systems) and direct instream loading from livestock as well as half of the wildlife direct deposition contribution.
- Scenario 6 represents the elimination of the human sources (failing sewage disposal systems) and direct instream loading from livestock as well as 75% of the wildlife direct deposition contribution.
- Scenario 7 represents the elimination of the human sources (failing sewage disposal systems), direct instream loading from livestock, 95% of the loading from agricultural nonpoint sources and 95% of the loading from urban non-point sources.
- Scenarios 8 and afterward represent elimination of human sources and various combinations of watershed-specific reductions to direct instream loading from cattle, agricultural non-point sources and urban non-point sources to achieve a 0% exceedance of the *E. coli* monthly geometric mean criterion and a no more than 10% exceedance of the *E. coli* maximum assessment criterion.

The following section discusses conclusions that can be made from the scenarios for each watershed.

4.4.1 Sugarland Run

1. In Scenario 0 (existing conditions), the water quality criteria resulted in a 22 percent exceedance of the *E. coli* geometric mean criterion and a 58 percent exceedance of the *E. coli* maximum assessment criterion.
2. In Scenario 2, elimination of the human sources (failing sewage disposal systems) and 50 percent of the livestock direct instream loading resulted in an 17 percent

exceedance of the *E. coli* geometric mean criterion and a 58 percent exceedance of the *E. coli* maximum assessment criterion.

3. In Scenario 6, eliminating the human sources (failing sewage disposal systems), livestock direct instream loading, and 75 percent of the instream loading from wildlife resulted in a zero exceedance of the *E. coli* geometric mean criterion and a 58 percent exceedance of the *E. coli* maximum assessment criterion.

4. Scenario 13 resulted in zero exceedances of the geometric mean criterion and a 10% reduction in the maximum assessment criterion.

Therefore, Scenario 13 was chosen as the final TMDL load allocation scenario for Sugarland Run. Under this scenario, complete elimination of human sources and livestock direct instream loadings, plus 97.3 percent reduction in both agricultural and urban non-point sources are required. No reductions are required for wildlife direct deposition. **Table 4-3** summarizes allocation scenarios for Sugarland Run.

Table 4-3: Sugarland Run Load Reductions Under 30-Day Geometric Mean and Maximum Assessment Criteria for *E. coli*

Scenario	Failing Sewage Disposal Systems	Direct Deposition from Livestock	Non-Point Source Agriculture	Urban*	Forest (Indirect Wildlife)	Direct Deposition from Wildlife	Percent Exceedance of the *E. coli* Geometric Mean Criterion	Percent Exceedance of the *E. coli* Maximum Assessment Criterion
	Proposed Percent Reduction for Each Scenario:							
0	0	0	0	0	0	0	22%	58%
1	100	0	0	0	0	0	17%	58%
2	100	50	0	0	0	0	17%	58%
3	100	100	0	0	0	0	16%	58%
4	100	100	100	100	0	0	0%	0%
5	100	100	0	0	0	50	3%	58%
6	100	100	0	0	0	75	0%	58%
7	100	100	95	95	0	0	0%	19%
8	100	100	85	85	0	0	2%	52%
9	100	100	90	90	0	0	1%	42%
10	100	50	50	50	0	0	8%	58%
11	100	75	75	75	0	0	3%	58%
12	100	100	97.2	97.2	0	0	0%	13%
13	**100**	**100**	**97.3**	**97.3**	**1**	**0**	**0%**	**10%**

**Urban runoff by nature is non-point source runoff. It includes regulated stormwater under the MS4 program, and non-regulated stormwater (e.g. non-MS4).*

4.4.2 Mine Run

1. In Scenario 0 (existing conditions), the water quality criteria resulted in a 0 percent exceedance of the *E. coli* geometric mean criterion and a 48 percent exceedance of the *E. coli* maximum assessment criterion.
2. In Scenario 2, elimination of the human sources (failing sewage disposal systems) and 50 percent of the livestock direct instream loading resulted in a 0 percent exceedance of the *E. coli* geometric mean criterion and a 45 percent exceedance of the *E. coli* maximum assessment criterion.
3. In Scenario 6, eliminating the human sources (failing sewage disposal systems), livestock direct instream loading, and 75 percent of the instream direct deposition loading from wildlife resulted in a 0 percent exceedance of the *E. coli* geometric mean criterion and a 45 percent exceedance of the *E. coli* maximum assessment criterion.
4. Scenario 8 resulted in zero exceedances of the geometric mean criterion and 10% exceedance of the maximum assessment criterion.

Therefore, Scenario 8 was chosen as the final TMDL load allocation scenario for Mine Run. Under this scenario, complete elimination of the human sources (failing sewage disposal systems) and livestock direct deposition, plus 94.1 percent reduction in both agricultural and urban non-point sources are required. No reductions are required for wildlife direct deposition. **Table 4-4** summarizes allocation scenarios for Mine Run.

Table 4-4: Mine Run Load Reductions Under 30-Day Geometric Mean and Maximum Assessment Criteria for *E. coli*

Scenario	Failing Sewage Disposal Systems	Direct Deposition from Livestock	Non-Point Source Agriculture	Urban*	Forest (Indirect Wildlife)	Direct Deposition from Wildlife	Percent Exceedance of the *E. coli* Geometric Mean Criterion	Percent Exceedance of the *E. coli* Maximum Assessment Criterion
	Proposed Percent Reduction for Each Scenario:							
0	0	0	0	0		0	0%	48%
1	100	0	0	0		0	0%	45%
2	100	50	0	0		0	0%	45%
3	100	100	0	0		0	0%	45%
4	100	100	100	100		0	0%	0%
5	100	100	0	0		50	0%	45%
6	100	100	0	0		75	0%	45%
7	100	100	95	95		0	0%	0%
8	**100**	**100**	**94.1**	**94.1**	**1**	**1**	**0%**	**10%**

**Urban runoff by nature is non-point source runoff. It includes regulated stormwater under the MS4 program, and non-regulated stormwater (e.g. non-MS4).*

4.4.3 Pimmit Run

1. In Scenario 0 (existing conditions), the water quality criteria resulted in a 33 percent exceedance of the *E. coli* geometric mean criterion and a 58 percent exceedance of the *E. coli* maximum assessment criterion.
2. In Scenario 2, elimination of the human sources (failing sewage disposal systems) and 50 percent of the livestock direct instream loading resulted in a 29 percent exceedance of the *E. coli* geometric mean criterion and a 58 percent exceedance of the *E. coli* maximum assessment criterion.
3. In Scenario 6, eliminating the human sources (failing sewage disposal systems), livestock direct instream loading, and 75 percent of the instream direct deposition loading from wildlife resulted in a 3 percent exceedance of the *E. coli* geometric mean criterion and a 58 percent exceedance of the *E. coli* maximum assessment criterion.
4. Scenario 13 resulted in zero exceedances of the geometric mean criterion and 9% exceedance of the maximum assessment criterion.

Therefore, Scenario 13 was chosen as the final TMDL load allocation scenario for Pimmit Run. Under this scenario, complete elimination of the human sources (failing sewage disposal systems) and livestock direct deposition and 99.42 percent reduction in both agricultural and urban non-point sources are required. No reductions are required for wildlife direct deposition. **Table 4-5** summarizes allocation scenarios for Pimmit Run.

Table 4-5: Pimmit Run Load Reductions Under 30-Day Geometric Mean and Maximum Assessment Criteria for *E. coli*

Scenario	Failing Sewage Disposal Systems	Direct Deposition from Livestock	Non-Point Source Agriculture	Urban*	Forest (Indirect Wildlife)	Direct Deposition from Wildlife	Percent Exceedance of the *E. coli* Geometric Mean Criterion	Percent Exceedance of the *E. coli* Maximum Assessment Criterion
	Proposed Percent Reduction for Each Scenario:							
0	0	0	0	0	0	0	33%	58%
1	100	0	0	0	0	0	29%	58%
2	100	50	0	0	0	0	29%	58%
3	100	100	0	0	0	0	29%	58%
4	100	100	100	100	0	0	0%	0%
5	100	100	0	0	0	50	14%	58%
6	100	100	0	0	0	75	3%	58%
7	100	100	95	95	0	0	1%	52%
8	100	100	80	80	0	0	13%	58%
9	100	100	85	85	0	0	11%	58%
10	100	100	90	90	0	0	2%	55%
11	100	50	50	50	0	0	22%	58%
12	100	75	75	75	0	0	15%	58%
13	**100**	**100**	**99.42**	**99.42**	**1**	**1**	**0%**	**9%**

**Urban runoff by nature is non-point source runoff. It includes regulated stormwater under the MS4 program, and non-regulated stormwater (e.g. non-MS4).*

4.5 Sugarland Run Allocation Plan and TMDL Summary

As shown in **Table 4-3**, Scenario 13 will meet the calendar-month *E. coli* geometric mean water quality criterion of 126 cfu/100 mL and the maximum assessment water quality criterion of 235 cfu/100 mL for Sugarland Run. The requirements for this scenario are:

- 100 percent reduction of the human sources (failing sewage disposal systems).
- 100 percent reduction of the direct instream loading from livestock.
- 97.3 percent reduction of bacteria loading from agricultural and urban nonpoint sources.

Table 4-6 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source.

Table 4-6: Sugarland Run Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Average *E. coli* Loads (cfu/yr)		Percent Reduction (%)
	Existing	Allocation	
Forest	2.53E+12	2.50E+12	1.0%
Cropland	7.36E+09	1.97E+08	97.3%
Pasture	1.19E+12	3.18E+10	97.3%
Urban/Non-MS4[1]	3.13E+13	8.38E+11	97.3%
Cattle - Direct Deposition	1.18E+11	0.00E+00	100.0%
Wildlife-Direct Deposition	3.99E+12	3.95E+12	1.0%
Failed Septics	8.91E+11	0.00E+00	100.0%
Permitted Point Source	0.00E+00	1.74E+09	-
Future Growth[2]		1.21E+11	-
SSOs	7.77E+07	0.00E+00	100.0%
MS4s	1.74E+14	4.65E+12	97.3%
Total	**2.14E+14**	**1.21E+13**	94.4%

(1) *The urban loads (non-MS4) include the load allocation (NPS loads) from high, medium, low intensity, and open space developed land use categories. It does not include bacteria load associated with MS4 areas.*
(2) *Future Growth allocation for point sources is calculated at 1 percent of the TMDL.*

The TMDL for Sugarland Run (annual loadings) is presented in **Table 4-7**.

Table 4-7: Sugarland Run TMDL (cfu/year) for *E. coli*

Watershed	WLA[1]	LA	MOS	TMDL
Sugarland Run	**4.78E+12**	**7.32E+12**	**Implicit**	**1.21E+13**

[1]Wasteload allocation includes allocated load for future growth of point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)

As mentioned in Section 4-3, the long-term average *E. coli* loads and coefficient of variations were determined to implement the final allocation scenarios and to express the TMDL on a daily basis. Assuming a log-normal distribution of data and a probability of occurrence of 95%, the maximum daily loads were determined using the approach outlined in the *USEPA OWOW 2007 Options for Expressing Daily Loads in TMDLs*. In reference to the daily expression equation presented in Section 4.2, the coefficient of variation in Sugarland Run watershed is 3.11.

A summary of the daily TMDL allocation plan loads for Sugarland Run is presented in **Table 4-8**.

Table 4-8: Sugarland Run TMDL (cfu/day) for *E. coli*				
Watershed	**WLA[1]**	**LA**	**MOS**	**TMDL**
Sugarland Run	**1.31E+10**	**7.72E+10**	**Implicit**	**9.03E+10**
[1]Wasteload allocation includes allocated load for future growth of point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)				

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figures 4-1** and **4-2**. **Figure 4-1** shows the calendar month geometric mean *E. coli* concentrations after applying the allocations of Scenario 13, as well as geometric mean loading under existing conditions. **Figure 4-2** shows the daily *E. coli* concentrations also under the allocations of Scenario 13 as well as the loadings under existing conditions. For Sugarland Run, allocation Scenario 13 results in bacteria concentrations that are consistently below both the geometric mean and maximum assessment criteria for *E. coli*.

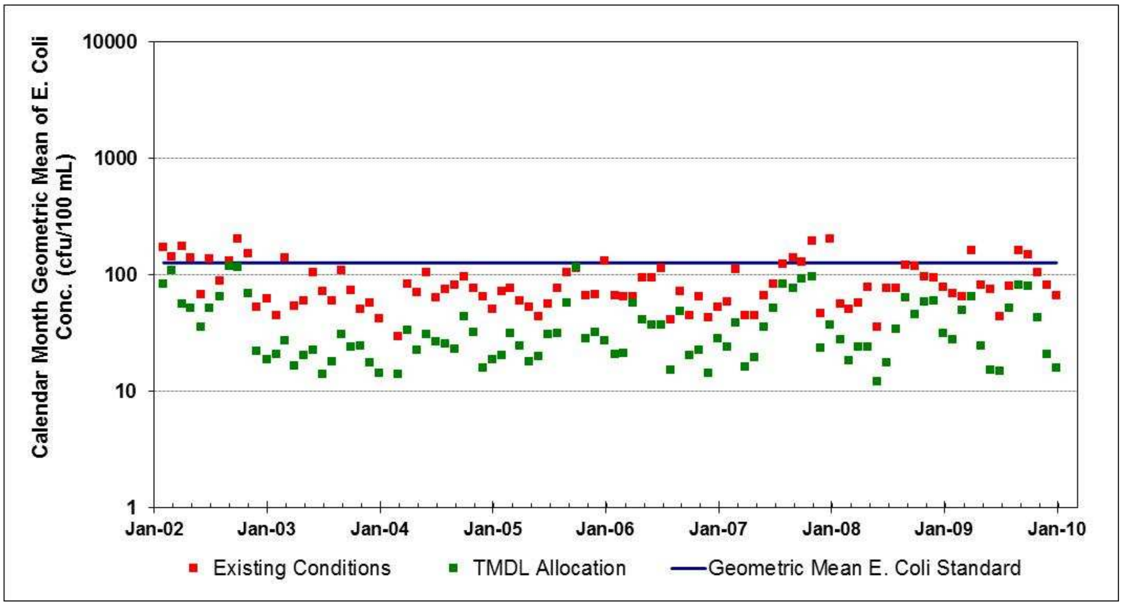


Figure 4-1: Sugarland Run Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 13

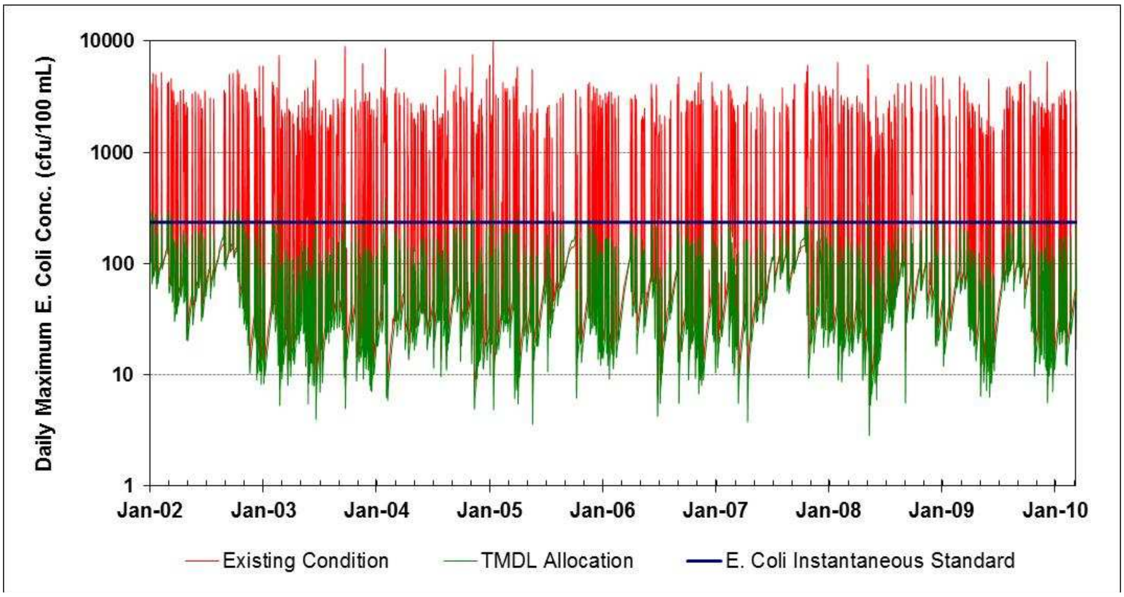


Figure 4-2: Sugarland Run Daily *E. coli* Concentrations under Allocation Scenario 13

4.6 Mine Run Allocation Plan and TMDL Summary

As shown in **Table 4-4**, Scenario 8 will meet the calendar-month *E. coli* geometric mean water quality criterion of 126 cfu/100 mL and the maximum assessment water quality criterion of 235 cfu/100 mL for Mine Run. The requirements for this scenario are:

- 100 percent reduction of the human sources (failing sewage disposal systems).
- 100 percent reduction of the direct instream loading from livestock.
- 94.1 percent reduction of bacteria loading from agricultural and urban nonpoint sources.

Table 4-9 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source.

Table 4-9: Mine Run Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Average *E. coli* Loads (cfu/yr)		Percent Reduction (%)
	Existing	Allocation	
Forest	3.39E+11	3.36E+11	1.0%
Cropland	8.82E+09	5.24E+08	94.1%
Pasture	9.63E+10	5.72E+09	94.1%
Urban/Non-MS4[1]	7.98E+12	4.74E+11	94.1%
Cattle - Direct Deposition	0.00E+00	0.00E+00	0.0%
Wildlife-Direct Deposition	2.21E+12	2.19E+12	1.0%
Failed Septics	2.21E+10	0.00E+00	100.0%
Future Growth[2]	0.00E+00	3.12E+10	-
SSOs	0.00E+00	0.00E+00	0.0%
MS4s	1.53E+12	9.12E+10	94.1%
Total	**1.22E+13**	**3.12E+12**	74.4%

(1) The urban loads (non-MS4) include the load allocation (NPS loads) from the open space developed land use category. It does not include bacteria load associated with MS4 areas.

(2) There are no individual VPDES municipal point source dischargers. The Future Growth allocation for point sources is calculated at 1 percent of the TMDL.

The TMDL for Mine Run (annual loading) is presented in **Table 4-10**.

Table 4-10: Mine Run TMDL (cfu/year) for *E. coli*

Watershed	WLA[1]	LA	MOS	TMDL
Mine Run	**1.22E+11**	**3.00E+12**	**Implicit**	**3.12E+12**

[1]Wasteload allocation includes allocated load for future growth of point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)

As mentioned in Section 4-3, the long-term average *E. coli* loads and coefficient of variations were determined to implement the final allocation scenarios and to express the TMDL on a daily basis. Assuming a log-normal distribution of data and a probability of occurrence of 95%, the maximum daily loads were determined using the approach outlined in the *USEPA OWOW 2007 Options for Expressing Daily Loads in TMDLs*.. In reference to the daily expression equation presented in Section 4.2, the coefficient of variation in Mine Run watershed is 2.92.

A summary of the daily TMDL allocation plan loads for Mine Run is presented in **Table 4-11**.

Table 4-11: Mine Run TMDL (cfu/day) for *E. coli*

Watershed	WLA[1]	LA	MOS	TMDL
Mine Run	3.35E+08	3.15E+10	Implicit	3.18E+10
[1]Wasteload allocation includes allocated load for future growth of point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)				

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figures 4-3** and **4-4**. **Figure 4-3** shows the calendar month geometric mean *E. coli* concentrations after applying the allocations of Scenario 8, as well as geometric mean loading under existing conditions. **Figure 4-4** shows the daily *E. coli* concentrations also under the allocations of Scenario 8 as well as the loadings under existing conditions. For Mine Run, allocation Scenario 8 results in bacteria concentrations that are consistently below both the geometric mean and maximum assessment criteria for *E. coli*.

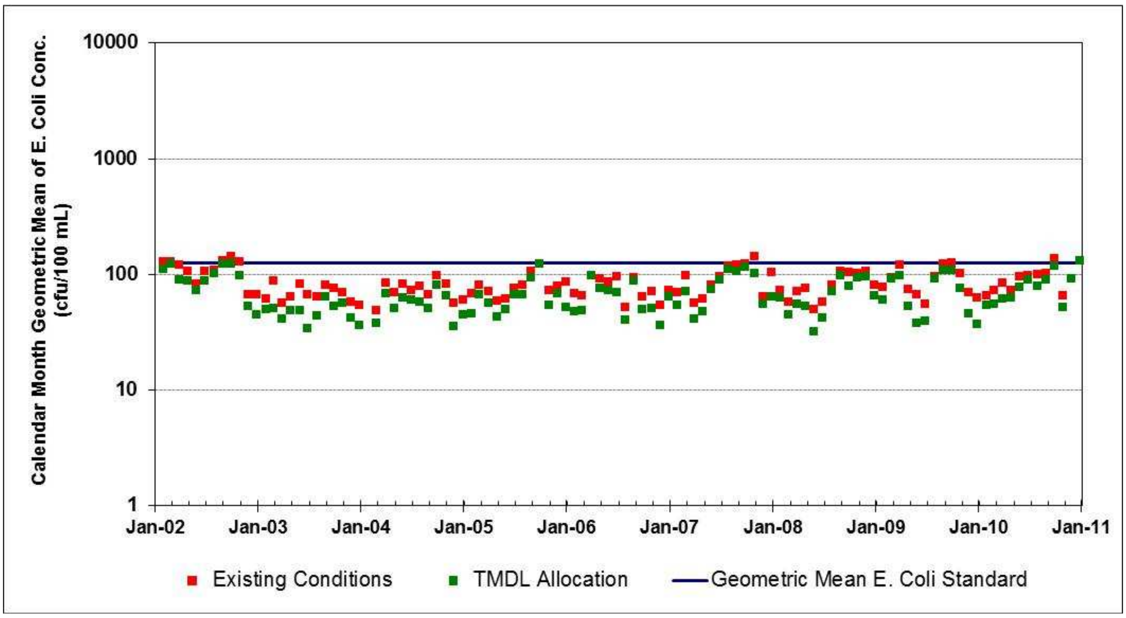


Figure 4-3: Mine Run Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 8

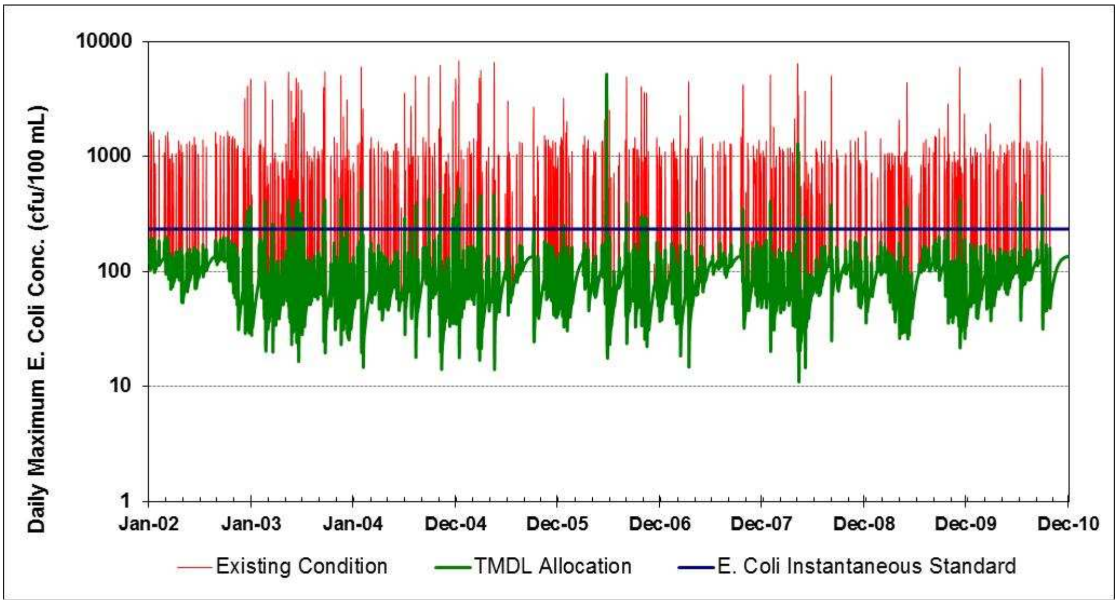


Figure 4-4: Mine Run Daily *E. coli* Concentrations under Allocation Scenario 8

4.7 Pimmit Run Allocation Plan and TMDL Summary

As shown in **Table 4-5**, Scenario 13 will meet the calendar-month *E. coli* geometric mean water quality criterion of 126 cfu/100 mL and the maximum assessment water quality criterion of 235 cfu/100 mL for Pimmit Run. The requirements for this scenario are:

- 100 percent reduction of the human sources (failing sewage disposal systems).
- 100 percent reduction of the direct instream loading from livestock.
- 99.4 percent reduction of bacteria loading from agricultural and urban non-point sources.

Table 4-12 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source.

Table 4-12: Pimmit Run Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation

Land Use/Source	Average *E. coli* Loads (cfu/yr)		Percent Reduction (%)
	Existing	Allocation	
Forest	1.35E+12	1.33E+12	1.00%
Cropland	3.08E+09	1.80E+07	99.42%
Pasture	2.68E+11	1.57E+09	99.42%
Urban/Non-MS4[1]	4.90E+13	2.86E+11	99.42%
Cattle - Direct Deposition	0.00E+00	0.00E+00	0.00%
Wildlife-Direct Deposition	3.08E+12	3.05E+12	1.00%
Failed Septics	5.30E+11	0.00E+00	100.00%
Future Growth[2]	0.00E+00	5.85E+10	-
SSOs	1.28E+10	0.00E+00	100.0%
MS4s	1.91E+14	1.12E+12	99.42%
Total	**2.45E+14**	**5.85E+12**	97.6%

(1) The urban loads (non-MS4) include the load allocation (NPS loads) from the open space developed land use category. It does not include bacteria load associated with MS4 areas.

(2) There are no individual VPDES municipal point source dischargers. The Future Growth allocation for point sources is calculated at 1 percent of the TMDL.

The yearly TMDL for Pimmit Run is presented in **Table 4-13**.

Table 4-13: Pimmit Run TMDLs (cfu/year) for *E. coli*

Watershed	WLA[1]	LA	MOS	TMDL
Pimmit Run	**1.17E+12**	**4.68E+12**	**Implicit**	**5.85E+12**

[1]Wasteload allocation includes allocated load for future growth of point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)

As mentioned in Section 4-3, the long-term average *E. coli* loads and coefficient of variations were determined to implement the final allocation scenarios and to express the TMDL on a daily basis. Assuming a log-normal distribution of data and a probability of occurrence of 95%, the maximum daily loads were determined using the approach outlined in the *USEPA OWOW 2007 Options for Expressing Daily Loads in TMDLs*. In reference to the daily expression equation presented in Section 4.2, the coefficient of variation in Pimmit Run watershed is 1.90.

A summary of the daily TMDL allocation plan loads for Pimmit Run is presented in **Table 4-14**.

Table 4-14: Pimmit Run TMDLs (cfu/day) for *E. coli*

Watershed	WLA[1]	LA	MOS	TMDL
Pimmit Run	**3.22E+09**	**4.56E+10**	**Implicit**	**4.88E+10**

[1]Wasteload allocation includes allocated load for future growth of point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figures 4-5** and **4-6**. **Figure 4-5** shows the calendar month geometric mean *E. coli* concentrations after applying the allocations of Scenario 13, as well as geometric mean loading under existing conditions. **Figure 4-6** shows the daily *E. coli* concentrations also under the allocations of Scenario 13 as well as the loading under existing conditions. For Pimmit Run, allocation Scenario 13 results in bacteria concentrations that are consistently below both the geometric mean and maximum assessment criteria for *E. coli*.

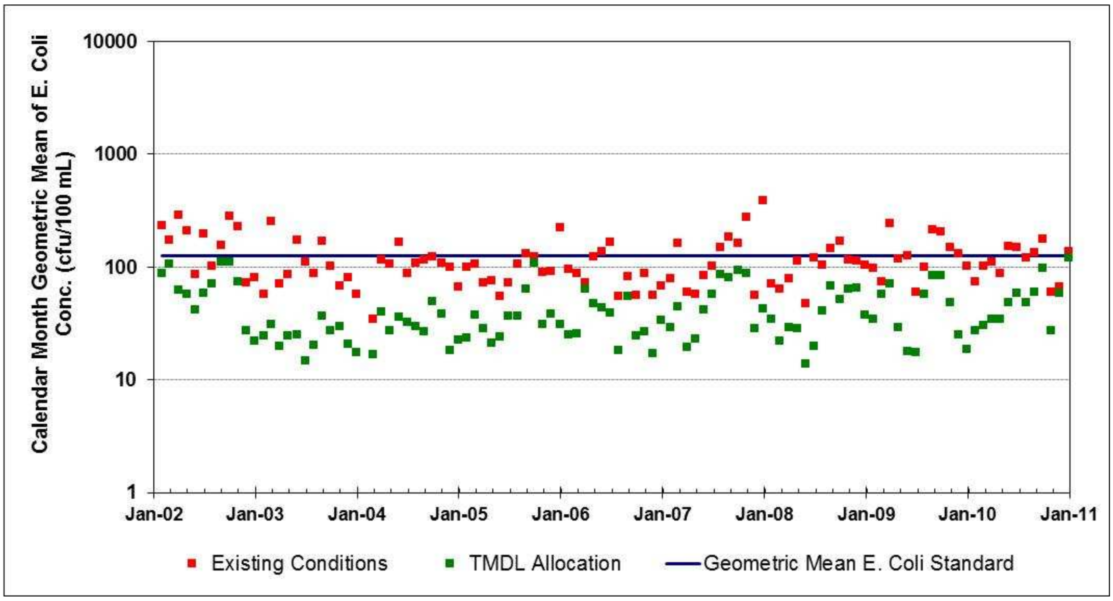


Figure 4-5: Pimmit Run Geometric Mean *E. coli* Concentrations under Existing Conditions and Allocation Scenario 13

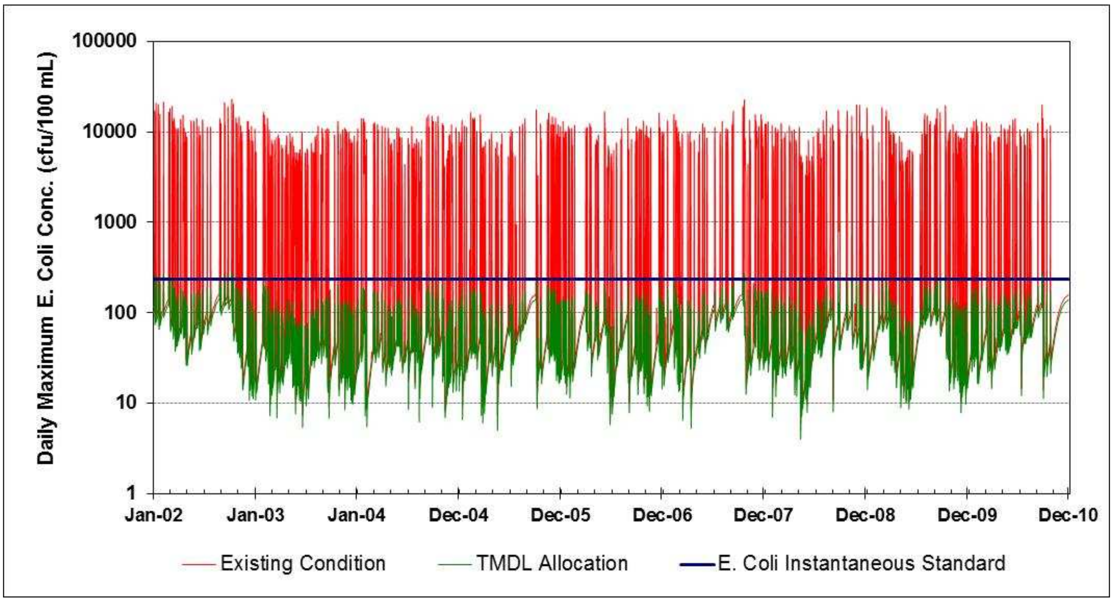


Figure 4-6: Pimmit Run Daily *E. coli* Concentrations under Allocation Scenario 13

5.0 TMDL Implementation and Reasonable Assurance

Once a TMDL has been approved by EPA, measures must be taken to reduce pollution levels from both point and non-point sources. The TMDL process involves three important steps: (1) TMDL Development, (2) Implementation Plan (IP) Development which is geared towards addressing nonpoint sources of the pollutant, and (3) implementation of the measures outlined in the TMDL, and the monitoring of stream water quality to assess progress and determine if water quality standards are attained. The following sections outline the framework used in Virginia to provide reasonable assurance that the required pollutant reductions can be achieved.

5.1 Continuing Planning Process and Water Quality Management Planning

As part of the Continuing Planning Process, DEQ staff will present both EPA-approved TMDLs and TMDL implementation plans to the State Water Control Board (SWCB) for inclusion in the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e) and Virginia's Public Participation Guidelines for Water Quality Management Planning.

DEQ staff will also request that the SWCB adopt TMDL WLAs as part of the Water Quality Management Planning Regulation (9VAC 25-720), except in those cases when permit limitations are equivalent to numeric criteria contained in the Virginia Water Quality Standards, such as in the case for bacteria. This regulatory action is in accordance with §2.2-4006A.4.c and §2.2-4006B of the Code of Virginia. SWCB actions relating to water quality management planning are described in the public participation guidelines referenced above and can be found on DEQ's web site under http://www.deq.state.va.us/tmdl/pdf/ppp.pdf.

5.2 Staged Implementation

In general, Virginia intends for the required control actions, including Best Management Practices (BMPs), to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. The iterative implementation of pollution control actions in the watershed has several benefits:

1. It enables tracking of water quality improvements following BMP implementation through follow-up stream monitoring.

2. It provides a measure of quality control, given the uncertainties inherent in computer simulation modeling.

3. It provides a mechanism for developing public support through periodic updates on BMP implementation and water quality improvements.

4. It helps ensure that the most cost effective practices are implemented first.

5. It allows for the evaluation of the adequacy of the TMDL in achieving water quality standards.

5.3 Implementation of Waste Load Allocations

Federal regulations require that all new or revised National Pollutant Discharge Elimination System (NPDES) permits must be consistent with the assumptions and requirements of any applicable TMDL WLA (40 CFR §122.44 (d)(1)(vii)(B)).

For the implementation of the WLA component of the TMDL, the Commonwealth utilizes the Virginia NPDES program (VPDES) and Virginia Stormwater Management Program (VSMP). Requirements of the permit process should not be duplicated in the TMDL process; depending on the type and nature of a point source discharge, it may be addressed through the development of TMDL implementation plans, or it may be addressed solely through the discharge permit. However, it is recognized that implementation plan development may help to coordinate the efforts of permitted sources through the collaborative process involved in development of the plan. The WLA requirements of the TMDL will be implemented through the referenced permit programs whether or not a TMDL implementation plan is developed.

5.3.1 Municipal (non-stormwater) Permits

This TMDL does not require reductions from municipal treatment plants with individual permits (there are none in the watersheds addressed by this TMDL) or general permits that discharge the contaminant of concern (only one in this TMDL, located in the Sugarland Run watershed). These facilities are required to meet the bacteria criterion of the Virginia WQS at the point of discharge as stipulated in their VPDES permit.

5.3.2 Stormwater Permits

There are separate state permitting programs that regulate the management of pollutants carried by stormwater runoff. Stormwater discharges associated with industrial activities are governed though the VPDES program, while stormwater discharges from construction sites and from municipal separate storm sewer systems (MS4s) are governed through the VSMP program. As with non-stormwater permits, all new or revised stormwater permits must be consistent with the assumptions and requirements of any applicable TMDL WLA. If a WLA is based on conditions specified in existing permits, and the permit conditions are being met, no additional actions may be needed. If a WLA is based on reduced pollutant loads, additional pollutant control actions will need to be implemented.

For MS4s/VSMP individual and general permits, the Commonwealth expects the permittee to specifically address the TMDL wasteload allocations (WLA) for stormwater through the iterative implementation of BMPs that may include both structural and nonstructural controls. Plans to comply with applicable WLAs are implemented through the MS4 permit. Additionally, permittees will be encouraged to participate in the development of TMDL implementation plans (IP) as recommendations from the IP process may need to be incorporated into the MS4 stormwater management program in order to be consistent with the TMDL.

It should be noted that implementation of the WLAs for MS4 permits will focus on achieving the percent reductions required by the TMDL, rather than the individual numeric WLAs. The MS4 WLAs are aggregated by geographic boundary. It is not intended that individual numeric WLAs will be applied towards each permit. Rather, the

MS4 permittees are expected to implement programmatic controls aimed at achieving the pollutant reductions identified in this TMDL. Additionally, it is anticipated that the implementation of MS4 WLAs will focus on reducing anthropogenic sources of the pollutant of concern.

Additional information on Virginia's Stormwater program and a downloadable menu of Best Management Practices and Measurable Goals Guidance can be found at http://www.dcr.virginia.gov/stormwater_management/stormwat.shtml.

5.3.3 TMDL Modifications for New or Expanding Dischargers

Permits issued for facilities with wasteload allocations developed as part of a TMDL must be consistent with the assumptions and requirements of these WLAs. In cases where a proposed permit modification is affected by a TMDL WLA, permit and TMDL staff must coordinate to ensure that new or expanding discharges meet this requirement. In 2005, DEQ issued guidance memorandum 05-2011 describing the available options and the process that should be followed under those circumstances, including public participation, EPA approval, State Water Control Board actions, and coordination between permit and TMDL staff. The guidance memorandum is available on DEQ's web site at http://www.deq.virginia.gov/waterguidance/

5.4 Implementation of Load Allocations

The TMDL program does not impart new implementation authorities. Therefore, the Commonwealth intends to use existing programs to the fullest extent in order to attain its water quality goals. The measures for non-point source reductions, which can include the use of better treatment technology and the installation of BMPs, are implemented in an iterative process that is described along with specific BMPs in the TMDL implementation plan.

5.4.1 Implementation Plan Development

A TMDL implementation plan will be developed that addresses, at a minimum, the requirements specified in the Code of Virginia, Section 62.1-44.19.7. State law directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters". The implementation plan "shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments." EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans, and milestones for attaining water quality standards.

In order to qualify for other funding sources, such as EPA's Section 319 grants, additional plan requirements may need to be met. The detailed process for developing an implementation plan has been described in the "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the DEQ and DCR TMDL project staff or at http://www.deq.virginia.gov/tmdl/implans/ipguide.pdf.

Watershed stakeholders will have opportunities to provide input and to participate in the development of the TMDL implementation plan. Regional and local offices of DEQ, DCR, and other cooperating agencies are technical resources to assist in this endeavor.

With successful completion of implementation plans, local stakeholders will have a blueprint to restore impaired waters and enhance the value of their land and water resources. Additionally, development of an approved implementation plan may enhance opportunities for obtaining financial and technical assistance during implementation.

5.4.2 Staged Implementation Scenarios

The purpose of the staged implementation scenarios is to identify one or more combinations of implementation actions that result in the reduction of controllable sources to the maximum extent practicable using cost-effective, reasonable BMPs for nonpoint source control. Some examples of effective bacterial BMPs for both urban and rural watersheds are the stream side fencing for cattle farms (rural areas), pet waste clean-up programs (urban and rural areas) and government grant programs available to homeowners with failing septic systems and installation of treatment systems for homeowners currently using straight pipes (predominantly rural areas).

VADEQ expects that implementation of the bacteria TMDLs will occur in stages, and that full implementation of the TMDLs is a long-term goal. Implementation efforts will focus on controlling anthropogenic sources. Actions identified during TMDL implementation plan development that go beyond what can be considered cost-effective and reasonable will only be included as implementation actions if there are reasonable grounds for assuming that these actions will in fact be implemented.

If water quality standards are not met upon implementation of all cost-effective and reasonable BMPs, a Use Attainability Analysis (UAA) may need to be initiated since Virginia's water quality standards allow for changes to use designations if existing water quality standards cannot be attained by implementing effluent limits required under §301b and §306 of Clean Water Act, and cost effective and reasonable BMPs for nonpoint source control. Additional information on UAAs is presented in Section 5.6, Addressing Wildlife Contributions and the attainability of Designated Uses.

5.4.3 Links to Ongoing Restoration Efforts

Implementation of this TMDL will contribute to on-going water quality improvement efforts aimed at restoring water quality in the Sugarland Run, Mine Run, and Pimmit Run watersheds. Currently, there are various organizations dedicated to protection and restoration of the Sugarland Run, Mine Run and Pimmit Run.

Citizen Monitoring Groups

The goal of Save Little Pimmit Run is to preserve, protect and restore the Little Pimmit Run watershed (a tributary to Pimmit Run). Currently there are serious problems of hazardous flash flooding, water quality contamination, bank erosion, stream bed scouring, and overall threat to the native habitat. The group works to encourage responsible stormwater and watershed management and implementation of best practices to stop the on-going degradation of the Little Pimmit and downstream waterways including the Potomac River and Chesapeake Bay.

Chesapeake Bay Program Ordinances

Fairfax County, Arlington County, and Loudoun County have all adopted Chesapeake Bay Program Ordinances which require stormwater BMPs for all new development or redevelopment.

Other Jurisdictional Programs

Fairfax County, Arlington County, and Loudoun County all have pet waste ordinances requiring proper disposal of pet wastes. All of the jurisdictions have programs for identifying illicit discharges to storm sewer systems, cleaning storm sewer catchments and basins, and rehabilitating sanitary sewers to prevent sanitary sewer overflow. Arlington County has a street sweeping program and VDOT, which maintains the roads in Fairfax County, also has a street sweeping program in that jurisdiction. Each jurisdiction is working to affect the behaviors and attitudes of the basin's citizens to non-point source pollution. For instance, outreach campaigns have been launched to address illegal dumping in storm drains. While some of these programs address broad water quality issues, some jurisdictions are also conducting directed outreach efforts relating to bacteria reduction. For example, the jurisdictions have made efforts to emphasize on proper dog walking habits and the watersheds' relationship to the Chesapeake Bay.

Arlington County Stream Restoration Efforts

Arlington County is currently in the process of completing watershed retrofit studies for all watersheds in their jurisdiction. The purpose of the studies is to find potential sites for new stormwater facilities. The study for Pimmit Run has been completed and 40 potential new stormwater facilities (such as street bioretention) have been identified. Several of these projects are already in the design phase. More information about these projects can be found on the Arlington County website at:

Pimmit Run Study:

http://www.arlingtonva.us/departments/EnvironmentalServices/cpe/page75627.aspx

Williamsburg Blvd. Median Bioretention Project:

http://www.arlingtonva.us/departments/EnvironmentalServices/epo/page81773.aspx#will

Full list of Watershed Retrofit Studies Ongoing:

http://www.arlingtonva.us/departments/EnvironmentalServices/epo/page67082.aspx

In addition, Arlington County recently completed a project with an advisory group from the Pimmit Run watershed to identify and define channel stability problems as well as potential flooding problems along the Little Pimmit Run stream corridor, and to develop conceptual design alternatives for adequately resolving any such identified problems. More information regarding this project can be found at:

http://www.arlingtonva.us/departments/EnvironmentalServices/cpe/page60407.aspx

Finally, Arlington County also performs water quality monitoring on many streams, including Pimmit Run. The following is a link to a webpage with a clickable map of the monitoring sites.

http://www.arlingtonva.us/departments/EnvironmentalServices/epo/page82828.aspx

Fairfax County Watershed Management Plans

The Fairfax County Board of Supervisors approved a Watershed Management Plan for Sugarland Run on December 7, 2010 and a Watershed Management Plan for the Middle Potomac Watersheds Group (including Pimmit Run) on May 5, 2008. A Board also approved a plan for the Nichol Run and Pond Branch Watersheds (includes Mine Run) on January 25, 2011. The goal of each of the plans was to present a strategy for preserving healthy ecosystems and improving the streams and natural environment within the watershed. The plans worked to identify watershed impairments, evaluate solutions for watershed restoration and preservation, and involved a Watershed Advisory Group to aid in plan development and project selection and prioritization (Fairfax County, 2011).

Loudoun County Citizen Groups and Watershed Activities

Loudoun Watershed Watch is a consortium of citizen groups, local and state authorities, and individuals concerned with the quality and health of streams in Loudoun County, Virginia. Initiated in 2000, Loudoun Watershed Watch promotes: environmental stewardship, countywide stream monitoring, watershed management planning, and water quality and stream habitat protection and restoration. In the Sugarland Run watershed, volunteers from Loudoun Wildlife Conservancy have been conducting benthic and habitat monitoring since the late 1990's. Loudoun County Government conducted a comprehensive stream assessment in 2009 with five benthic and eight habitat stations in the Sugarland Run watershed."

5.4.4 Implementation Funding Sources

The implementation of pollutant reductions from non-regulated non-point sources relies heavily on incentive-based programs, while the funding sources for regulated discharges can be varied depending on the type of discharge. Therefore, the identification of funding sources for non-regulated implementation activities is a key to success. Cooperating agencies, organizations and stakeholders must identify potential funding sources available for implementation during the development of the implementation plan in accordance with the "Virginia Guidance Manual for Total Maximum Daily Load Implementation Plans". The TMDL Implementation Plan Guidance Manual contains information on a variety of funding sources and government agencies that might support implementation efforts, as well as suggestions for integrating TMDL implementation with other watershed planning efforts.

Some of the major potential sources of funding for non-regulated implementation actions may include EPA Section 319 funds, Virginia State Revolving Loan Program (also available for permitted activities), Virginia Agricultural Best Management Practices Cost-Share Programs, Virginia Water Quality Improvement Fund (available for both point and nonpoint source pollution), tax credits and landowner contributions. With additional appropriations for the Water Quality Improvement Fund during recent legislative sessions, the Fund has become a significant funding stream for WWTPs. Additionally, funding is being made available to address urban and residential water quality problems. Information on WQIF projects and allocations can be found at http://www.deq.virginia.gov/bay/wqif.html

and at http://www.dcr.virginia.gov/sw/wqia.htm.

5.5 Follow-Up Monitoring

Following the development of the TMDL, DEQ will make every effort to continue to monitor the impaired stream in accordance with its ambient monitoring programs. DEQ's Ambient Watershed Monitoring Plan for conventional pollutants calls for watershed monitoring to take place on a monthly basis for one year, with flexibility for watershed rotation yearly. In accordance with DEQ Guidance Memo No. 03-2004, during periods of reduced resources, monitoring can temporarily discontinue until the TMDL staff determines that implementation measures to address the source(s) of impairments are being installed. The purpose, location, parameters, frequency, and duration of the monitoring will be determined by DEQ staff, in cooperation the Implementation Plan Steering Committee and local stakeholders. Whenever possible, the location of the follow-up monitoring station(s) will be the same as the listing station. At a minimum, the monitoring station must be representative of the original impaired segment. The details of the follow-up monitoring will be outlined in the Annual Water Monitoring Plan prepared by each DEQ Regional Office. Other agency personnel, watershed stakeholders, etc. may provide input on the Annual Water Monitoring Plan. These recommendations must be made to the DEQ regional TMDL coordinator by September 30 of each year. **Table 5-1** provides a summary of the water quality monitoring stations in the Sugarland Run, Mine Run, and Pimmit Run bacteria impaired watersheds.

Table 5-1: VA DEQ Water Quality Stations

Station ID	Stream
1ASUG004.42	Sugarland Run
1AMNR000.72	Mine Run
1APIM004.16	Pimmit Run
1APIM001.89	Pimmit Run
1APIM001.76	Pimmit Run
1ALIO000.15	Little Pimmit Run
1APIM000.15	Pimmit Run
1ALIO001.50	Little Pimmit Run

DEQ staff, in cooperation the Implementation Plan Steering Committee and local stakeholders, will continue to use data from the ambient monitoring stations to evaluate reductions in pollutants ("water quality milestones" as established in the implementation plan), the effectiveness of the TMDL in attaining and maintaining water quality standards, and the success of implementation efforts. Recommendations may then be made, when necessary, to target implementation efforts in specific areas and continue or discontinue monitoring at follow-up stations.

In some cases, watersheds will require monitoring above and beyond what is included in DEQ's standard monitoring plan. Ancillary monitoring by citizens' or watershed groups, local government, or universities is an option that may be used in such cases. An effort should be made to ensure that ancillary monitoring follows established QA/QC guidelines in order to maximize compatibility with DEQ monitoring data. In instances where citizens' monitoring data is not available and additional monitoring is needed to assess the effectiveness of targeting efforts, TMDL staff may request of the monitoring managers in each regional office an increase in the number of stations or monitor existing stations at a higher frequency in the watershed. The additional monitoring beyond the original bimonthly single station monitoring will be contingent on staff resources and available laboratory budget. More information on citizen monitoring in Virginia and QA/QC guidelines is available at http://www.deq.virginia.gov/cmonitor/.

To demonstrate that the watershed is meeting water quality standards in watersheds where corrective actions have taken place (whether or not a TMDL or implementation plan has been completed), DEQ must meet the minimum data requirements from the original listing station or a station representative of the originally listed segment. The minimum data requirement for conventional pollutants (bacteria, dissolved oxygen, etc.) is bimonthly monitoring for two consecutive years. For biological monitoring, the minimum requirement is two consecutive samples (one in the spring and one in the fall) in a one year period.

5.6 Addressing Wildlife Contributions and the Attainability of Designated Uses

In some streams for which TMDLs have been developed, water quality modeling indicates that even after removal of all bacteria sources (other than wildlife), the stream will not attain standards under all flow regimes at all times. Virginia and USEPA are not proposing the elimination of natural wildlife to allow for the attainment of water quality standards. However, managing overpopulations of wildlife remains an option available to local stakeholders. During the implementation plan development phase of a TMDL process, and in consultation with a local government or land owner(s), should the Department of Game and Inland Fisheries (VDGIF) determine that a population of resident geese, deer or other wildlife is at "nuisance" levels, measures to reduce such populations may be deemed acceptable if undertaken under the supervision, or issued permit, of the VDGIF or the U.S. Fish and Wildlife Service as appropriate. Additional information on VDGIF's wildlife programs can be found at http://www.dgif.virginia.gov/hunting/va_game_wildlife/.

If water quality standards are not being met, a use attainability analysis (UAA) may be initiated to reflect the presence of naturally high bacteria levels due to uncontrollable sources. In some cases, the effort may never have to go to the UAA phase because the water quality standard exceedances attributed to wildlife in the model may have been very small and infrequent and within the margin of error.

In some streams for which TMDLs have been developed, factors may prevent the stream from attaining its designated use. In order for a stream to be assigned a new designated use, or a subcategory of a use, the current designated use must be removed. To remove a designated use, the state must demonstrate that the use is not an existing use, and that downstream uses are protected. Such uses will be attained by implementing effluent limits required under §301b and §306 of Clean Water Act and by implementing cost-effective and reasonable best management practices for nonpoint source control (9 VAC 25-260-10 paragraph I).

The state must also demonstrate that attaining the designated use is not feasible because of one or more of the following reasons:

1. Naturally occurring pollutant concentration prevents the attainment of the use.

2. Natural, ephemeral, intermittent or low flow conditions prevent the attainment of the use unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating state water conservation.

3. Human-caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place.

4. Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate the modification in such a way that would result in the attainment of the use.

5. Physical conditions related to natural features of the water body, such as the lack of proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life use protection.

6. Controls more stringent than those required by §301b and §306 of the Clean Water Act would result in substantial and widespread economic and social impact.

This and other information is collected through a special study called a UAA. All site-specific criteria or designated use changes must be adopted by the SWCB as amendments to the water quality standards regulations. During the regulatory process, watershed stakeholders and other interested citizens, as well as the EPA, will be able to provide comment during this process. Additional information can be obtained at

http://www.deq.virginia.gov/wqs/pdf/WQS05A_1.pdf

The process to address potentially unattainable reductions based on the above is as follows:

As a first step, measures targeted at the controllable, anthropogenic sources identified in the TMDL's staged implementation scenarios will be implemented. In addition, measures should be taken to ensure that discharge permits are fully implementing provisions required in the TMDL. The expectation would be for the reductions of all controllable sources to the maximum extent practicable using the implementation approaches described above. DEQ will continue to monitor water quality in the streams during and subsequent to the implementation of these measures to determine if water quality standards are being attained. This effort will also help to evaluate if the modeling assumptions used in the TMDL were correct. In the best-case scenario, water quality goals will be met and the stream's uses fully restored using effluent controls and BMPs. If, however, water quality standards are not being met, and no additional effluent controls and BMPs can be identified, a UAA would then be initiated with the goal of re-designating the stream for a more appropriate use or subcategory of a use.

A 2006 amendment to the Code of Virginia under 62.1-44.19:7E. provides an opportunity for aggrieved parties in the TMDL process to present to the State Water Control Board reasonable grounds indicating that the attainment of the designated use for a water is not feasible. The Board may then allow the aggrieved party to conduct a use attainability analysis according to the criteria listed above and a schedule established by the Board. The amendment further states that "If applicable, the schedule shall also address whether TMDL development or implementation for the water shall be delayed."

6.0 Public Participation

The development of the Sugarland Run, Mine Run and Pimmit Run TMDLs would not have been possible without public participation. Three technical advisory committee (TAC) meetings and two public meetings were held for this project. The following is a summary of the meetings.

TAC Meeting No. 1: The first TAC meeting was held on March 1, 2011 at the DEQ Northern Regional Office in Woodbridge, Virginia. The purpose of this meeting was to provide information on the steps required in the TMDL process and to explain the types of data used in the development of bacteria TMDLs.

TAC Meeting No. 2: The second TAC meeting was held on September 14, 2011 at the Great Falls Public Library in Great Falls, Virginia. The purpose of this meeting was to discuss the preliminary source assessment for the Sugarland Run, Mine Run and Pimmit Run watersheds.

TAC Meeting No. 3: The third TAC meeting was held on November 16, 2011 at the Great Falls Public Library in Great Falls, Virginia. The purpose of this meeting was to provide information on the model calibration and validation results, as well as the preliminary TMDL bacteria allocation scenarios for Sugarland Run, Mine Run and Pimmit Run.

Public Meeting No. 1: The first public meeting was held on April 13, 2011 at the Great Falls Public Library in Great Falls, Virginia. The purpose of this meeting was to introduce the TMDL process to the public and explain the steps required in developing bacteria TMDLs for Sugarland Run, Mine Run, and Pimmit Run. Information regarding the potential bacteria sources in the watershed was also presented. Twelve people attended the meeting. Copies of the presentation were available for the public both at the meeting and on the DEQ website. This meeting was advertised in the *Virginia Register*. Written comments were received during the 30-day comment period and DEQ provided written responses to these comments.

Public Meeting No. 2: The second public meeting was held on December 14, 2011 at the Great Falls Public Library in Great Falls, Virginia. The purpose of this meeting was to present the final TMDL results for Sugarland Run, Mine Run, and Pimmit Run. Thirteen people attended the meeting. Copies of the presentation and the draft report were available for the public both at the meeting and through the DEQ website. This meeting was publically noticed in the *Virginia Registrar*. Three sets of written comments were received during the 30-day comment period.

References

American Society of Agricultural Engineers, (ASAE) 1998. ASAE standards, 45^{th} edition.

American Veterinary Medical Association Website (2007). Available at < https://www.avma.org/KB/Resources/Statistics/Pages/Market-research-statistics-US-pet-ownership.aspx#formulas >

Arlington County. 2011. Personal Correspondence for Livestock Inventory Revisions and Septic Information.

Fairfax County. 2011. Personal Correspondence for Septic Information.

Horsley and Witten. 1996. Identification and evaluation of nutrient and bacterial loadings to Maquoit Bay, New Brunswick and Freeport, Maine.

Long Island Regional Planning Board (LIRPB). 1978. Long Island Comprehensive Waste Treatment Management Plan, Volumes I and II. Hauppauge, NY.

Loudoun County. 2011. Personal Correspondence for Livestock Inventory Revisions and Septic Information.

Loudoun County Soil and Water Conservation District. 2011. Personal Correspondence for Livestock Inventory Revisions.

Lumb and Kittle, 1993. Users Manual for an Expert System (HSPEXP) for Calibration of the Hydrological Simulation Program-Fortran. U.S. Geological Survey, Virginia.

Metcalf and Eddy. 1991. Wastewater Engineering: Treatment, Disposal, Reuse. 3^{rd} Ed. McGraw-Hill, Inc, New York.

National Climatic Data Center. 2011. First Order Summary of the Day and Hourly Precipitation Data. http://www.ncdc.noaa.gov/

NOAA (2006). *Coastal NLCD Classification Scheme.* National Oceanic and Atmospheric Administration. Available at: http://www.csc.noaa.gov/crs/lca/tech_cls.html

Swann, C. 1999. *A Survey of Residential Nutrient Behaviors in the Chesapeake Bay*. Widener Burrows, Inc. Chesapeake Research Consortium. Center for Watershed Protection. Ellicott City, MD

U.S. Census Bureau. 1990. 1990 U.S. Census Data for Virginia. Available at <http://www.census.gov/>

U.S. Census Bureau. 2000. 2000 State and County Quick Facts, Virginia. Available at <http://quickfacts.census.gov/qfd/states/51/51121.html>

U.S. Department of Agriculture, Natural Resource Conservation Service (NRCS). 2010a. Soil Survey Geographic (SSURGO) Database for Virginia. Available at http://soildatamart.nrcs.usda.gov

U.S. Department of Agriculture, Natural Resource Conservation Service (NRCS). 2010b. Geospatial Data Gateway. Available at: http://datagateway.nrcs.usda.gov

U.S. Department of Agriculture. 2007 Agricultural Census. Available at <http://www.agcensus.usda.gov/Publications/2007/Full_Report/index.asp>

U.S. Environmental Protection Agency (EPA). 1985. Rates, Constants, and Kinetics formulations in Surface Water Quality Modeling. Athens, GA.

U.S. Environmental Protection Agency (EPA). 1991. Guidance for Water Quality-Based Decisions: The TMDL Process. Available at <http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/decisions_index.cfm>

U.S. Environmental Protection Agency (EPA). 2001a. Better Assessment Science Integrating Point and Nonpoint Sources (BASINS), Version 3 Washington, DC.

U.S. Environmental Protection Agency (EPA). 2001b. EPA 841-R-00-002. Protocols for developing Pathogen TMDLs. Available at <http://www.epa.gov/owow/tmdl/pathogen_all.pdf >

U.S. Environmental Protection Agency (EPA). 2005. "Overview or Current Total Maximum Daily Load (TMDL) Program and Regulations." Available at <http://www.epa.gov/owow/tmdl/overviewfs.html > Website visited August, 2005.

U.S. Environmental Protection Agency (EPA). 2007. Options for Expressing Daily Loads in TMDLs. Available at <http://www.epa.gov/owow/tmdl/draft_daily_loads_tech.pdf>

U.S. Geological Survey. 2008. National Hydrography Dataset. Available at : http://nhd.usgs.gov/

U.S. Geological Survey. 2011. National Water Information System. Available at : http://waterdata.usgs.gov/nwis/inventory?search_criteria=search_site_no&submitted_form=introduction

Virginia. *State Water Control Board.* 2006. 9 VAC 25-260. Virginia Water Quality Standards. Available at <http://www.deq.virginia.gov/wqs.html >

Virginia Department of Environmental Quality (DEQ). 2003. *Guidance Manual for Total Maximum Daily Load Implementation Plans.* Available at <http://www.deq.state.va.us/tmdl/implans/ipguide.pdf >

Virginia Department of Environmental Quality (DEQ). 2003. *Guidance Memo No. 03-2012 HSPF model Calibration and Verification for Bacteria TMDLs*.

Virginia Department of Environmental Quality (DEQ). 2004b. "Total Maximum Daily Loads, Background-Legal and Regulatory Framework." Available at <http://www.deq.state.va.us/tmdl/backgr.html>

Virginia Department of Environmental Quality (DEQ). 2005. "TMDL Modifications in Response to New or Expanding Discharges." Available at <http://www.deq.virginia.gov/waterguidance/pdf/052011.pdf>

Virginia Department of Environmental Quality (DEQ). 2005. "Total Maximum Daily Loads." Available at <http://www.deq.state.va.us/tmdl>

Virginia Department of Environmental Quality (DEQ). 2006. Final 2006 305(b)/303(d) *Water Quality Assessment Integrated Report.* Available at < http://www.deq.state.va.us/wqa/ir2006.html>

Virginia Department of Environmental Quality (DEQ). 2011. Final 2010 305(B)/303(D) Water Quality Assessment Integrated Report. Available at <http://www.deq.state.va.us/wqa/ir2010.html>

Virginia Department of Environmental Quality (DEQ). 2011b. Datasets relating to TMDL Development.

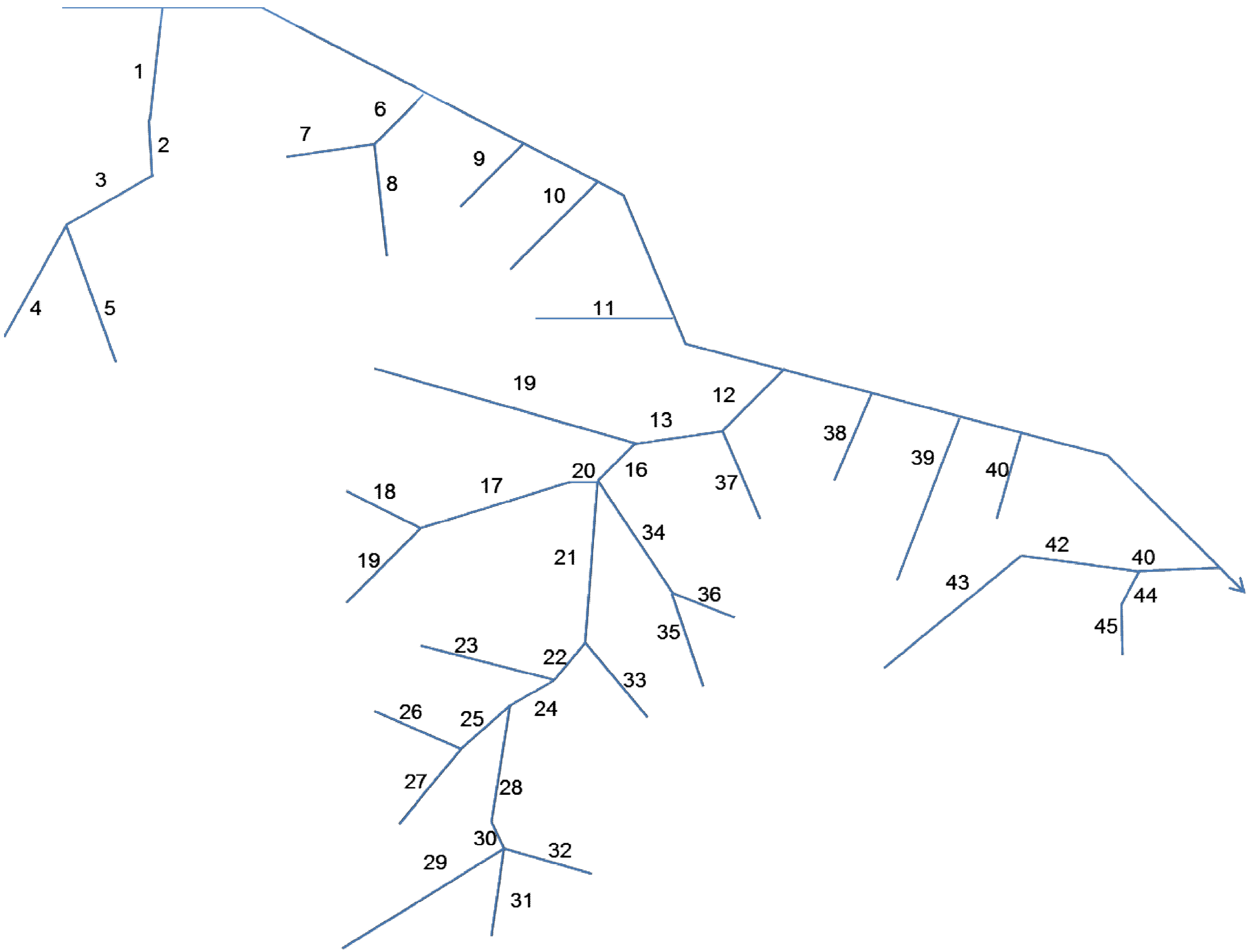
Virginia Department of Game and Inland Fisheries (DGIF). 2011. Personal Correspondence for Wildlife Inventory of Birds and Deer.

Virginia Tech, 2000. Fecal Coliform TMDL for Sheep Creek, Elk Creek, Machine Creek, Little Otter River, and Lower Big Otter River in Bedford and Campbell Counties, Virginia. Available at <http://www.deq.virginia.gov/tmdl/apptmdls/roankrvr/bigotter.pdf>

Weldon-Cooper Center for Public Service. 2011. Virginia's Horse Industry: Characteristics and Economic Contributions. Available at <http://www.coopercenter.org/sites/default/files/publications/VA_Newsltr0711.pdf>

APPENDIX A:

Model Representation of Stream Reach Networks



Model Representation of Tributaries to the Potomac River: Sugarland Run, Mine Run, and Pimmit Run

APPENDIX B:

Monthly Fecal Coliform Build-up Rates and Direct Deposition Loads

Table B- 1: Sugarland Run Monthly Build-up Rates (January to June)						cfu/ac/day
Land Use	**Jan**	**Feb**	**Mar**	**April**	**May**	**Jun**
Cropland	8.99E+06	8.99E+06	1.12E+07	1.35E+07	1.29E+07	1.29E+07
Forest	5.74E+07	5.74E+07	5.74E+07	4.09E+07	4.09E+07	4.09E+07
Residential	1.32E+09	1.32E+09	1.32E+09	1.22E+09	1.22E+09	1.22E+09
Pasture	2.28E+09	2.28E+09	2.29E+09	2.19E+09	2.19E+09	2.19E+09

Table B- 2: Sugarland Run Monthly Build-up Rates (July to December)						cfu/ac/day
Land Use	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Cropland	1.29E+07	1.29E+07	1.36E+07	1.12E+07	8.99E+06	8.99E+06
Forest	4.09E+07	4.09E+07	4.09E+07	5.74E+07	5.74E+07	5.74E+07
Residential	1.22E+09	1.22E+09	1.22E+09	1.32E+09	1.32E+09	1.32E+09
Pasture	2.19E+09	2.19E+09	2.19E+09	2.29E+09	2.28E+09	2.28E+09

Table B- 3: Mine Run Monthly Build-up Rates (January to June)						cfu/ac/day
Land Use	**Jan**	**Feb**	**Mar**	**April**	**May**	**Jun**
Cropland	2.30E+07	2.30E+07	2.80E+07	3.32E+07	3.18E+07	3.18E+07
Forest	5.12E+07	5.12E+07	5.12E+07	4.06E+07	4.06E+07	4.06E+07
Residential	8.76E+08	8.76E+08	8.76E+08	8.12E+08	8.12E+08	8.12E+08
Pasture	4.90E+08	4.90E+08	4.96E+08	4.38E+08	4.36E+08	4.36E+08

Table B- 4: Mine Run Monthly Build-up Rates (July to December)						cfu/ac/day
Land Use	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Cropland	3.18E+07	3.18E+07	3.34E+07	2.80E+07	2.30E+07	2.30E+07
Forest	4.06E+07	4.06E+07	4.06E+07	5.12E+07	5.12E+07	5.12E+07
Residential	8.12E+08	8.12E+08	8.12E+08	8.76E+08	8.76E+08	8.76E+08
Pasture	4.36E+08	4.36E+08	4.38E+08	4.96E+08	4.90E+08	4.90E+08

Table B- 5: Pimmit Run Monthly Build-up Rates (January to June)				cfu/ac/day		
Land Use	**Jan**	**Feb**	**Mar**	**April**	**May**	**Jun**
Cropland	3.49E+07	3.49E+07	3.49E+07	3.49E+07	3.49E+07	3.49E+07
Forest	1.41E+08	1.41E+08	1.41E+08	8.75E+07	8.75E+07	8.75E+07
Residential	6.95E+09	6.95E+09	6.95E+09	6.47E+09	6.47E+09	6.47E+09
Pasture	3.42E+09	3.42E+09	3.42E+09	2.96E+09	2.96E+09	2.96E+09

Table B- 6: Pimmit Run Monthly Build-up Rates (July to December)				cfu/ac/day		
Land Use	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Cropland	3.49E+07	3.49E+07	3.49E+07	3.49E+07	3.49E+07	3.49E+07
Forest	8.75E+07	8.75E+07	8.75E+07	1.41E+08	1.41E+08	1.41E+08
Residential	6.47E+09	6.47E+09	6.47E+09	6.95E+09	6.95E+09	6.95E+09
Pasture	2.96E+09	2.96E+09	2.96E+09	3.42E+09	3.42E+09	3.42E+09

Table B- 7: Sugarland Run Direct Deposition Rates (cfu/day)			
Month	Direct Cattle	Direct Septic	Direct Wildlife
1	1.71E+08	3.09E+11	1.40E+10
2	1.71E+08	3.09E+11	1.40E+10
3	2.59E+08	3.09E+11	1.40E+10
4	3.47E+08	3.09E+11	1.40E+10
5	3.47E+08	3.09E+11	1.40E+10
6	4.36E+08	3.09E+11	1.40E+10
7	4.36E+08	3.09E+11	1.40E+10
8	4.36E+08	3.09E+11	1.40E+10
9	3.47E+08	3.09E+11	1.40E+10
10	2.59E+08	3.09E+11	1.40E+10
11	2.59E+08	3.09E+11	1.40E+10
12	1.71E+08	3.09E+11	1.40E+10

Table B- 8: Mine Run Monthly Direct Deposition Rates (cfu/day)

Month	Direct Cattle	Direct Septic	Direct Wildlife
1	0.00 E+00	6.32E+09	7.01E+09
2	0.00 E+00	6.32E+09	7.01E+09
3	0.00 E+00	6.32E+09	7.01E+09
4	0.00 E+00	6.32E+09	7.01E+09
5	0.00 E+00	6.32E+09	7.01E+09
6	0.00 E+00	6.32E+09	7.01E+09
7	0.00 E+00	6.32E+09	7.01E+09
8	0.00 E+00	6.32E+09	7.01E+09
9	0.00 E+00	6.32E+09	7.01E+09
10	0.00 E+00	6.32E+09	7.01E+09
11	0.00 E+00	6.32E+09	7.01E+09
12	0.00 E+00	6.32E+09	7.01E+09

Table B- 9: Pimmit Run Monthly Direct Deposition Rates (cfu/day)

Month	Direct Cattle	Direct Septic	Direct Wildlife
1	0.00 E+00	2.33E+11	1.11E+10
2	0.00 E+00	2.33E+11	1.11E+10
3	0.00 E+00	2.33E+11	1.11E+10
4	0.00 E+00	2.33E+11	1.11E+10
5	0.00 E+00	2.33E+11	1.11E+10
6	0.00 E+00	2.33E+11	1.11E+10
7	0.00 E+00	2.33E+11	1.11E+10
8	0.00 E+00	2.33E+11	1.11E+10
9	0.00 E+00	2.33E+11	1.11E+10
10	0.00 E+00	2.33E+11	1.11E+10
11	0.00 E+00	2.33E+11	1.11E+10
12	0.00 E+00	2.33E+11	1.11E+10

Appendix C

Abbreviations and Glossary

Abbreviations

AVMA: American Veterinary Medical Association
BMP: Best Management Practice
CWA: Clean Water Act
DEM: Digital Elevation Model
EPA: Environmental Protection Agency
HSPEXP: Expert System for Calibration of the Hydrological Simulation Program-FORTRAN
HSPF: Hydrologic Simulation Program-Fortran
HUC: Hydrologic Unit Code
LA: Load Allocation
MS4: Municipal separate storm sewer system
NCDC: National Climatic Data Center
NHD: National Hydrography Dataset
NLCD: National Land Coverage Database
NOAA: National Oceanic and Atmospheric Association
NRO: Northern Regional Office
NPDES: National Pollution Discharge Elimination System
NRCS: Natural Resources Conservation Service
MOS: Margin of Safety
SSURGO: Soil Survey Geographic
SWCB: State Water Control Board
SWCD: Soil and Water Conservation District
TAC: Technical Advisory Committee
TMDL: Total Maximum Daily Load
USGS: U.S. Geological Survey
VADCR: Virginia Department of Conservation and Recreation
VADEQ: Virginia Department of Environmental Quality
VADGIF: Virginia Department of Game and Inland Fisheries
VDH: Virginia Department of Health
VDMME: Virginia Department of Mines, Minerals, and Energy
VPDES: Virginia Pollutant Discharge Elimination System
VSMP: Virginia Stormwater Management Program
UAA: Use Attainability Analysis
USDA: United States Department of Agriculture
WLA: Wasteload Allocation
WQIF: Water Quality Improvement Fund
WQMIRA: Water Quality Monitoring, Information, and Restoration Act

Glossary

303(d). A section of the Clean Water Act of 1972 requiring states to identify and list water bodies that do not meet the states' water quality standards.

Allocations. That portion of receiving water's loading capacity attributed to one of its existing or future pollution sources (non-point or point) or to natural background sources. (A wasteload allocation [WLA] is that portion of the loading capacity allocated to an existing or future point source, and a load allocation [LA] is that portion allocated to an existing or future non-point source or to natural background levels. Load allocations are best estimates of the loading, which can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting loading.)

Ambient water quality. Natural concentration of water quality constituents prior to mixing of either point or non-point source load of contaminants. Reference ambient concentration is used to indicate the concentration of a chemical that will not cause adverse impact on human health.

Anthropogenic. Pertains to the [environmental] influence of human activities.

Bacteria. Single-celled microorganisms. Bacteria of the coliform group are considered the primary indicators of fecal contamination and are often used to assess water quality.

Bacterial source tracking (BST). A collection of scientific methods used to track sources of fecal contamination.

Biosolids. Also known as Sewage sludge, is the name for the solid, semisolid, or liquid materials removed during the treatment of domestic sewage in a treatment facility. Biosolids include, but are not limited to, solids removed during primary, secondary, or advanced wastewater treatment, scum, domestic septage, portable toilet pumpings, Type III marine sanitation device pumpings, and sewage sludge products. When properly treated and processed, sewage sludge becomes "biosolids" which can be safely recycled and applied as fertilizer to improve and maintain productive soils and stimulate plant growth.

Best management practices (BMPs). Methods, measures, or practices determined to be reasonable and cost-effective means for a landowner to meet certain, generally non-point source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.

Clean Water Act (CWA). The Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972), Public Law 92-500, as amended by Public Law 96-483 and Public Law 97-117, 33 U.S.C. 1251 et seq. The Clean Water Act (CWA) contains a number of provisions to restore and maintain the quality of the nation's water resources. One of these provisions is section 303(d), which establishes the TMDL program.

Concentration. Amount of a substance or material in a given unit volume of solution; usually measured in milligrams per liter (mg/L) or parts per million (ppm).

Contamination. The act of polluting or making impure; any indication of chemical, sediment, or biological impurities.

Cost-share program. A program that allocates project funds to pay a percentage of the cost of constructing or implementing a best management practice. The remainder of the costs is paid by the producer(s).

Critical condition. The critical condition can be thought of as the "worst case" scenario of environmental conditions in the waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. Critical conditions are the combination of environmental factors (e.g., flow, temperature, etc.) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence.

Designated uses. Those uses specified in water quality standards for each waterbody or segment whether or not they are being attained.

Domestic wastewater. Also called sanitary wastewater, consists of wastewater discharged from residences and from commercial, institutional, and similar facilities.

Drainage basin. A part of a land area enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into a receiving water. Also referred to as a watershed, river basin, or hydrologic unit.

Existing use. Use actually attained in the waterbody on or after November 28, 1975, whether or not it is included in the water quality standards (40 CFR 131.3).

Fecal Coliform. Indicator organisms (organisms indicating presence of pathogens) associated with the digestive tract.

Geometric mean. A measure of the central tendency of a data set that minimizes the effects of extreme values.

GIS. Geographic Information System. A system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth. (Dueker and Kjerne, 1989)

Infiltration capacity. The capacity of a soil to allow water to infiltrate into or through it during a storm.

Interflow. Runoff that travels just below the surface of the soil.

Loading, Load, Loading rate. The total amount of material (pollutants) entering the system from one or multiple sources; measured as a rate in weight per unit time.

Load allocation (LA). The portion of a receiving waters loading capacity attributed either to one of its existing or future non-point sources of pollution or to natural background sources. Load allocations are best estimates of the loading, which can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and non-point source loads should be distinguished (40 CFR 130.2(g)).

Loading capacity (LC). The greatest amount of loading a water body can receive without violating water quality standards.

Margin of safety (MOS). A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving water body (CWA section 303(d)(1)©). The MOS is normally incorporated into the conservative assumptions used to develop TMDLs (generally within the calculations or models) and approved by EPA either individually or in state/EPA agreements. If the MOS needs to be larger than that which is allowed through the conservative assumptions, additional MOS can be added as a separate component of the TMDL (in this case, quantitatively, a TMDL = LC = WLA + LA + MOS).

Mean. The sum of the values in a data set divided by the number of values in the data set.

Monitoring. Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.

Narrative criteria. Non-quantitative guidelines that describe the desired water quality goals.

Non-point source. Pollution that originates from multiple sources over a relatively large area. Non-point sources can be divided into source activities related to either land or water use including failing septic tanks, improper animal-keeping practices, forest practices, and urban and rural runoff.

Numeric targets. A measurable value determined for the pollutant of concern, which, if achieved, is expected to result in the attainment of water quality standards in the listed waterbody.

Point source. Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water waterbody or river.

Pollutant. Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. (CWA section 502(6)).

Pollution. Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, biological, chemical, and radiological integrity of water.

Poultry Litter. A material used as bedding in poultry operations. Common litter materials are woodshavings, sawdust, peanut hulls, shredded sugar cane, straw, and other dry, absorbent, low-cost organicmaterials. After use, the litter consists primarily of poultry manure, but also contains the original littermaterial, feathers, and spilled feed.

Privately owned treatment works. Any device or system that is (a) used to treat wastes from any facility whose operator is not the operator of the treatment works and (b) not a publicly owned treatment works.

Public comment period. The time allowed for the public to express its views and concerns regarding action by EPA or states (e.g., a Federal Register notice of a proposed rule-making, a public notice of a draft permit, or a Notice of Intent to Deny).

Publicly owned treatment works (POTW). Any device or system used in the treatment (including recycling and reclamation) of municipal sewage or industrial wastes of a liquid nature that is owned by a state or municipality. This definition includes sewers, pipes, or other conveyances only if they convey wastewater to a POTW providing treatment.
Raw sewage. Untreated municipal sewage.

Receiving waters. Creeks, streams, rivers, lakes, estuaries, ground-water formations, or other bodies of water into which surface water and/or treated or untreated waste are discharged, either naturally or in man-made systems.

Riparian areas. Areas bordering streams, lakes, rivers, and other watercourses. These areas have high water tables and support plants that require saturated soils during all or part of the year. Riparian areas include both wetland and upland zones.

Riparian zone. The border or banks of a stream. Although this term is sometimes used interchangeably with floodplain, the riparian zone is generally regarded as relatively narrow compared to a floodplain. The duration of flooding is generally much shorter, and the timing less predictable, in a riparian zone than in a river floodplain.

Runoff. That part of precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into receiving waters.

Septic system. An on-site system designed to treat and dispose of domestic sewage. A typical septic system consists of a tank that receives waste from a residence or business and a drain field or subsurface absorption system consisting of a series of percolation lines for the disposal of the liquid effluent. Solids (sludge) that remain after decomposition by bacteria in the tank must be pumped out periodically.

Sewer. A channel or conduit that carries wastewater and storm water runoff from the source to a treatment plant or receiving stream. Sanitary sewers carry household, industrial, and commercial waste. Storm sewers carry runoff from rain or snow. Combined sewers handle both.

Slope. The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25 or 1 on 25, indicating one unit vertical rise in 25 units of horizontal distance, or in a decimal fraction (0.04), degrees (2 degrees 18 minutes), or percent (4 percent).

Stakeholder. Any person with a vested interest in the TMDL development.

Surface area. The area of the surface of a waterbody; best measured by planimetry or the use of a geographic information system.

Surface runoff. Precipitation, snowmelt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of non-point source pollutants.

Surface water. All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors directly influenced by surface water.

Topography. The physical features of a geographic surface area including relative elevations and the positions of natural and man-made features.

Total Maximum Daily Load (TMDL). The sum of the individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for non-point sources and natural background, plus a margin of safety (MOS). TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state's water quality standard.

VADEQ. Virginia Department of Environmental Quality.

VDH. Virginia Department of Health.

Virginia Pollutant Discharge Elimination System (NPDES). The national program for issuing, modifying, revoking and re-issuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Clean Water Act.

Wasteload allocation (WLA). The portion of a receiving waters' loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality-based effluent limitation (40 CFR 130.2(h)).

Wastewater. Usually refers to effluent from a sewage treatment plant. See also **Domestic wastewater**.

Wastewater treatment. Chemical, biological, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water to remove, reduce, or neutralize contaminants.

Water quality. The biological, chemical, and physical conditions of a waterbody. It is a measure of a waterbody's ability to support beneficial uses.

Water quality criteria. Levels of water quality expected to render a body of water suitable for its designated use, composed of numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or states for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Water quality standard. Law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement.

Watershed. A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

WQIA. Water Quality Improvement Act.